IDENTIFYING RELEVANT VARIABLES FOR UNDERSTANDING HOW SCHOOL FACILITIES AFFECT EDUCATIONAL OUTCOMES

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Identifying Relevant Variables for Understanding How School Facilities Affect Educational Outcomes

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DEDICATION

For our soon-to-arrive baby boy

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First and foremost, I would like to acknowledge the source of all good things, the Lord God almighty. He will never leave nor forsake those who believe in Him (Hebrews 13:5) and He has promised that I can do all things through Christ who gives me strength (Philippians 4:13). I have been blessed with everything I need to live my life for Him.

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goals. Of course, they would also understand if I changed my mind mid-course and chose another path. There is no greater comfort than knowing that if everything collapsed around me, they would be there to help me get going again. I have never needed anything that they have not been willing to lovingly provide. I am also thankful for my sister and her family who also live in the Atlanta area and for my brother and his family in Tennessee for loving me so much.

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SUMMARY

Many school facilities in the United States are old, out-of-date, poorly maintained, and lack specific design elements that are likely to enhance teaching, learning, behavior, and other desirable outcomes. This study proposed that one reason why previous research regarding the effects of the physical school environment on educational outcomes has had little impact on the quality of schools is because there is a lack of knowledge about these relationships. A multi-method approach was used to solicit information from educators and researchers familiar with school facility effects literature to develop a set of research priorities to guide future research. In Phase I, a literature analysis provided important physical and outcome variables to seed brainstorming lists used in following phases of the research and provided the basis for a gap analysis to identify unavailable information. A concept mapping methodology was utilized in Phase II to solicit feedback from a group of seventeen experienced educators who were asked to brainstorm a list of measures of student, school, or school district success, sort their final list of more than 100 items into categories that made sense to them, and rate each item regarding how important it is to monitor or otherwise track. Using a Delphi method, a series of four questionnaires was given to a group of experienced researchers who developed a list of physical variables plausibly related to educational outcomes, rated the importance of those items, developed hypotheses that included top-rated physical variables and top-rated outcome variables (i.e., measures of success rated by educators), and then selected from those hypotheses several that became the basis of the recommended research priorities for the field. These research priorities propose investigations of the relationships between a set of physical

variables (including the provision of team work stations and faculty collaborative spaces, well-designed circulation spaces, spaces for quiet reflection, adaptable seating, daylighting in classrooms, and overall maintenance and building quality) and a variety of educational outcomes (e.g., achievement, behavior, satisfaction, affective performance).

CHAPTER 1

RESEARCH PROBLEM

Background

Many of our nation's students attend schools that are old, outdated, uncomfortable and even unsafe. The average age of school facilities in the U.S. is forty-two years (Rowand 1999), many needing major renovations. Approximately $127 billion is needed to bring schools up to good overall condition (Lewis et al., 2000). According to Lewis, when surveyed about satisfaction with environmental conditions, including lighting, heating, ventilation, indoor air quality, acoustics or noise control, and physical security of buildings, forty-three percent of the schools responding reported at least one environmental factor as being unsatisfactory. Nearly one third of schools surveyed reported inadequate condition of heating, ventilation and air conditioning systems.

School construction spending is at an all-time high. During the period from 1990 through 1997, total school construction spending increased thirty-nine percent (from $17.8 billion to $24.7 billion), while school enrollment increased only twelve percent during that time period (U.S. General Accounting Office, 2000). Increasing enrollment and a push for smaller class sizes are creating a greater need for school construction and renovation. In 2001, school districts spent a record $28.6 billion on school construction (Agron, 2002), with approximately fifty-eight percent going toward additions and modernizations. It is projected that school districts will allocate nearly $108 billion for school construction between 2002 and 2004. Perhaps never before has there been such an opportunity to positively affect educational environments to ensure that they enhance teaching and learning, while providing safe, healthy, and comfortable schools. How can researchers contribute to the fulfillment of that goal?

Problem Statement

For researchers to contribute to the development of better schools, *it is important to understand how school facilities affect students and other building occupants.* Researchers from various fields (e.g., education, environment-behavior) and sub-specialties (e.g., indoor air quality, lighting design) have provided evidence that the physical environment in school facilities, such as lighting, acoustics, and overall condition, affects various types of educational outcomes - academic achievement and behavior, for example (Christie and Glickman, 1980; Evans and Maxwell, 1997; Heshong Mahone Group, 1999; Green, 1974; Grandgaard, 1995; Bowers and Burkett 1987; Maxwell, 1999). Yet, in spite of past research efforts, it is still not common practice to incorporate research findings into the design and operation of school facilities.

There are three primary obstacles to the utilization of research, according to Knott and Wildavsky (1980). These include: a lack of knowledge; decision-makers are unaware of the knowledge that does exist; and/or, decision-makers are aware of the knowledge that exists but refuse to adopt it. Within each of these broad categories, there is likely a large number of factors affecting why research regarding school facilities to date has not significantly affected the way schools are designed and operated, such as the availability of funding, poor communication between researchers and practitioners, organizational barriers to implementing innovative facility designs, etc. There is an entire body of literature dedicated to "research utilization" or "knowledge utilization" and a discussion of that domain is outside the scope of this study.

This research investigates one aspect of research utilization - whether or not there is a lack of knowledge in the field. There are many questions surrounding school facility effects that remain unanswered. For example, how do school facilities enhance or detract from the learning process? What are the mediating factors? How do school facilities affect student behavior? What are the causal relationships among correlated variables? Although studies exist that have examined the effects of overall building conditions, building age, finishes, lighting, noise, humidity, class size, and other conditions on educational outcomes, the results are scattered, many studies have not been published beyond a Master's thesis or doctoral dissertation, and few studies have been replicated.

While there is still much to learn about school facility effects on students, teachers and other occupants, *a formally stated set of research priorities for understanding these relationships does not exist*. It is important to identify research priorities for the field because there are likely thousands of physical variables and educational outcomes that could be studied. Without a formal set of research priorities, researchers will continue to make progress in this area, but a set of priorities may help move the field in a fruitful direction more quickly AND with the buy-in needed to secure funding to conduct relevant research. Funding for research is limited, and selecting priorities will help focus available funding dollars to deliver the most "bang for the buck". It is important that research priorities address the needs of practitioners. Lackney (1996, p. 25) suggested that environment-behavior research regarding school environments has not led to improvements in environmental quality because "it has not, in many cases, addressed problems, concerns, issues and questions of relevance to educational practitioners," due partly to the differences in interests and goals of researchers and practitioners. It is not surprising that a clearly defined set of priorities does not exist because those working in this field come from a variety of research backgrounds. In fact, it is difficult even to name the field since it includes those from environment-behavior, education, building technology, and other disciplines. A chemist may study the effects of a specific type of technology on the indoor air quality in schools and the occurrence of student health complaints, while an architect may investigate how teachers modify their classrooms to compensate for building designs that do not meet their teaching needs. Nevertheless, the common link between these researchers is their interest in the school facility and its effect on occupants. Therefore, throughout this document, the term “School Facility Effects (SFE) researcher” will be used to describe any researcher that focuses (at one time or another) on school environments and how they affect building occupants.

Scope and Objectives

It is perhaps as important to state what this study is *not* about as it is to state what it accomplishes. This study is not an experiment that examines links between specific physical variables and educational outcomes. Therefore, it is quite different from the majority of the studies included in the literature analysis (Chapter 3). Secondly, this study does not attempt to identify and describe ideal learning environments based on new and existing research findings to provide design guidance. Thirdly, this study does not investigate decision processes of school stakeholders, nor produce a decision support strategy. Rather, this study is specifically designed to accomplish the following four primary objectives:

- Identify physical variables and educational outcomes that have been studied in the SFE literature.

- Identify measures of student, school, or school district success that are important to teachers and administrators (dependent variables).
- Identify physical variables (independent variables) and potential moderators (such as demographics, maintenance, or teacher quality) that likely influence the selected measures of success, as perceived by experienced researchers in the field.
- Develop a set of research priorities to guide future research.

This study uses qualitative research methods to accomplish these objectives. It is different from most other studies in this field because it acquires data from both researchers who study school environments and educators (i.e., practitioners) who work in them to identify research priorities that affect both of these groups, as well as other school stakeholders, such as designers and building managers. There are several studies that provide the context in which this study is embedded.

Two seminal references, Weinstein (1979) and McGuffey (1982), provided comprehensive reviews of SFE-related research and a foundation for more recent work. One similarity to this current doctoral study is that these authors identified future research directions. Through her review, Weinstein (1979) recommended that researchers conduct studies regarding relationships between physical school design and educational program (e.g., spaces that support a variety of teaching and learning styles) and develop design guidance based on that research. Also, she acknowledged that researchers must design studies (and interpret them) appropriately to account for the complexity of environment-behavior relationships. Methodological rigor is crucial to advancing the field, she concluded. Although McGuffey (1982) does not specifically state recommended research priorities, his extensive review of the literature identified areas of weakness in which more research was needed.

This current work is somewhat similar to a study conducted by Lackney (1996). His research, conducted in five Baltimore city schools, used an action research method to identify which elements of environmental quality school stakeholders (parents, students, teachers, administrators, and non-instructional staff) believe affect educational outcomes. Through a workshop and teacher surveys, he found that the environmental quality criteria perceived to affect *student academic performance* include: physical comfort and health; classroom adaptability; safety and security; building functionality; personalization and ownership; and privacy. Environmental quality aspects perceived to affect *student social development* included: physical comfort and health; safety and security; personalization and ownership; aesthetics and appearance; classroom adaptability; building functionality; and places for social interaction. And those aspects perceived to affect *teacher instructional performance* included: physical comfort and health; classroom adaptability; safety and security; and building functionality. Lackney also found that four of the ten environmental qualities identified were related to facility management, including physical comfort and health, safety and security, personalization and ownership, and aesthetics and appearance. He observed, "on the whole, all schools experienced problems that were perceived as under the influence of facility management."

In a related study conducted by Heery International (2000), researchers conducted three focus groups with teachers and more than 1500 telephone interviews (with teachers principals, and assistant principals) in nine metropolitan areas (statewide in Oregon and Massachusetts) to learn more about educators' opinions regarding how school design and school conditions affect educational outcomes. Ninety-nine percent of the respondents considered school design and condition to be important for school safety, and ninety-nine percent also reported that they are important for creating a good learning environment. Similarly, ninety-seven percent believed that they are important for academic achievement, while eighty-eight percent reported them as important for teacher retention. A significant number of educators who had experienced construction projects in their schools rated contractors a “C” or below in how they maintain communications, minimize teacher inconvenience, and schedule construction noise around class times. This study also found that lighting and climate control are two of the most important design elements for educators and that most desire autonomy in the classrooms, including the ability to control the climate and to decorate. Other important design elements included sufficient technology, space, flexibility, and windows. Safety was a very important consideration for educators.

Whereas the Lackney and Heery studies sought to understand educators’ perceptions about how their schools affect educational outcomes, this particular study involved educators in the identification of important educational outcomes. Relying on their knowledge and professional experience, they were asked to identify the most important measures of student, school, or school district success, irrespective of whether or not those measures may be affected by the physical school building. Experienced researchers, rather than educators, were asked to identify plausible links between physical conditions and those measures of success. The primary focus of this study was the identification of those relationships, and it resulted in a recommended set of research priorities for the SFE field.

As previously stated, this dissertation focused specifically on whether or not there is a lack of knowledge regarding school facility effects on educational outcomes. Although there are likely many variables that contribute to a child's academic achievement, health, comfort, psychological well being and other important outcomes, this research was limited to the physical school facility and those variables that are likely to moderate or mediate their effects. This study addressed only K-12 schools because these facilities are designed for intentional teaching and learning, house a large number of occupants, and young people spend an enormous amount of time inside them.

A series of three types of studies were executed to address the problems stated above: an analysis of the literature; the use of concept mapping techniques to identify measures of student, school, and school district success that are important to educators; and a Delphi method for identifying the most important physical variables (and hypotheses to describe plausible relationships with educational outcomes). A synthesis of these studies was used to develop a set of SFE research priorities.

Research Questions

The specific questions addressed in this study included:

1. What physical variables and education outcomes have been studied in the SFE literature?
2. What are the most important educational outcomes (i.e., measures of student, school, or school district success), as perceived by educators (specifically principals, teachers and guidance counselors)?
3. Are there important educational outcomes (as perceived by educators) that have been overlooked in past evaluations?

4. What are the most important physical variables that affect student outcomes, as perceived by those who are experienced in conducting SFE research?
5. Are there important physical variables (as perceived by SFE researchers) that have been overlooked in past studies?
6. If the data indicate that there is a gap in existing knowledge about links between physical school facilities and educational outcomes, what research priorities will focus efforts on the most plausible links?

Significance

The problem concerning our lack of understanding of school facility effects on students and teachers is gaining national attention. During 2002, President Bush's *No Child Left Behind Act* was passed, including amendments from Sen. Hillary Clinton's "Healthy and High Performance Schools Act." Recognizing that there is a need for research such as the project proposed here, the Act calls for a national study to assess the health and learning impacts of environmentally unhealthy schools on students and teachers. The Secretary of Education has been authorized to conduct various studies, including one that examines the "characteristics of those public elementary and secondary school buildings that contribute to unhealthy school environments" (personal communication, October 2, 2002). This present study supports the goals of the Department of Education.

This dissertation most directly assists SFE researchers, but may indirectly support other school decision makers, including educators, school designers, and building managers by focusing future research efforts to acquire knowledge that is relevant to them. Although there is much more to research utilization than knowledge creation, this is the first step towards ensuring that research informs practice to create better school environments for student, teachers and other building occupants. This study is an important step in improving our understanding of the links between physical school variables and measures of student, school, or school district success, ultimately contributing to the development of better schools and smarter, more well-rounded students. Figure 1.1 shows how focused research can benefit school occupants in the long-term.

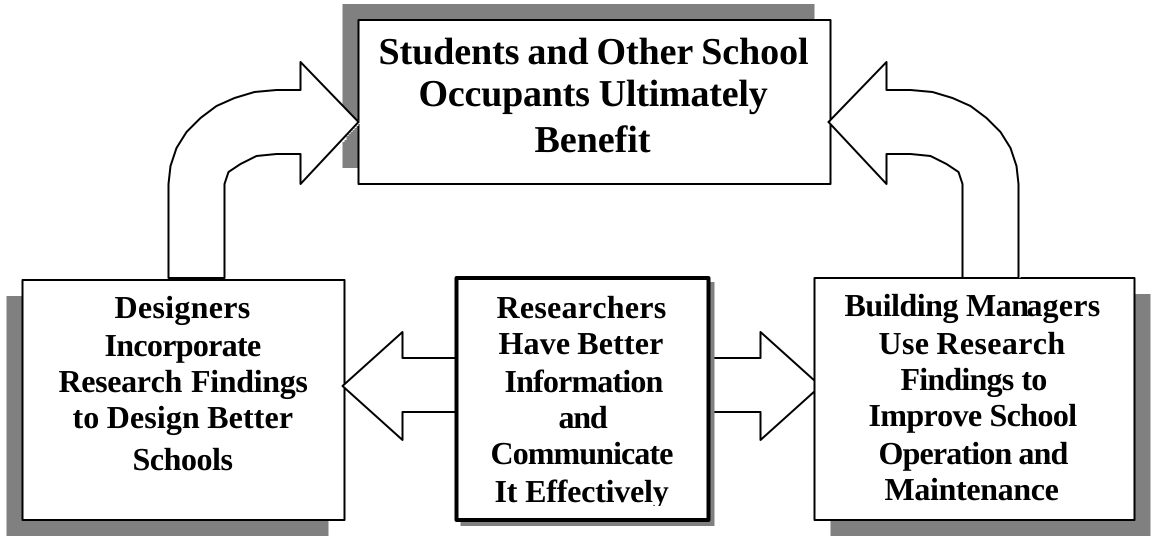


Figure 1.1 Student Benefits From School Facility Effects Research

If SFE researchers are to have a greater impact on the types of schools that are built and how they are operated, it is imperative that they continue to strive towards providing information that will directly assist school decision-makers and designers. Properly equipped, school stakeholders will design, construct, operate and maintain schools to enhance student achievement, improve the health of building occupants, and provide other benefits yet to be identified. Specific contributions of this study are listed below.

Contributions of This Research

This study provides a number of important contributions, including:

- The application of a combination of qualitative methods for identifying high priority variables (based on input from stakeholders from a variety of sub-specialties) within a broad field of research
- A list of measures of student, school, and school district success that educators believe are important to monitor or otherwise track.
- A concept map that clusters the measures of success into broad categories for consideration by researchers
- A set of high-priority hypotheses recommended for testing in the near-term by SFE researchers
- A recommended set of research priorities for the SFE field

The development of each of these contributions is described in detail in the following chapters. Chapter 2 provides an overview of the research design and methods utilized in this study. Chapter 3 describes the literature analysis. Chapters 4 and 5 describe the concept mapping exercise with educators and the Delphi process with experienced researchers. In Chapter 6, research priorities have been proposed, based on the findings reported in Chapters 3 though 5. A summary of the findings derived from this study and recommended next steps are reported in Chapter 7.

Definitions of Terms

Building manager: the person responsible for the operation, maintenance, and repair of a school facility. This person's title may vary from school to school, but "building manager" is used throughout this document.

Educators: in this study, educators include principals, assistant principals, teachers and guidance counselors.

Educational outcomes: any type of outcome that may be affected as a result of school attendance. In this document, used interchangeably with measures of student, school, or school district success.

Guidance document: a document written specifically to provide recommendations for improving school design, construction, operation and/or maintenance.

Measures of student, school, or school district success: any type of outcome that may be affected as a result of school attendance. In this document, used interchangeably with educational outcomes. This term was specifically chosen for use with educators who may not relate to the term "educational outcomes."

Mediator: variable that interprets or explains relationships between independent and dependent variables (Evans and Lepore, 1997)

Moderator: variable that interacts with independent variables to influence the outcome (Evans and Lepore, 1997)

Operationalize: to define variables in such a manner that they may be consistently measured during research studies

Outcome variable: dependent variable

Physical variable: any type of physical condition or attribute (e.g., daylighting, seating configuration, faculty collaborative spaces) that may affect educational outcomes.

Research priorities: a set of topics, including specific hypotheses, that are perceived to be important to study in the near-term.

SFE researchers: researchers who have experience evaluating the effects of school facilities on educational outcomes. These researchers come from a wide variety of disciplines and sub-specialty areas.

CHAPTER 2

RESEARCH DESIGN AND METHODS

Overview

The problems described in Chapter 1 were addressed in this study using a four-phase approach. First, in Phase I, an analysis of the SFE literature provided a framework for understanding the types of relationships that have already been studied, and it identified variables for seeding brainstorming exercises that were utilized in Phases II and III. In Phase II, a group of educators identified important measures of student, school, and school district success then rated the importance of those items and grouped them into clusters. In Phase III, a group of experienced SFE researchers identified physical variables most plausibly linked to educational outcomes and developed hypotheses to be studied in the near-term. Finally, in Phase IV, these data were synthesized into a research agenda for the SFE field. Figure 2.1 lists each of these four phases in the order in which they were conducted.

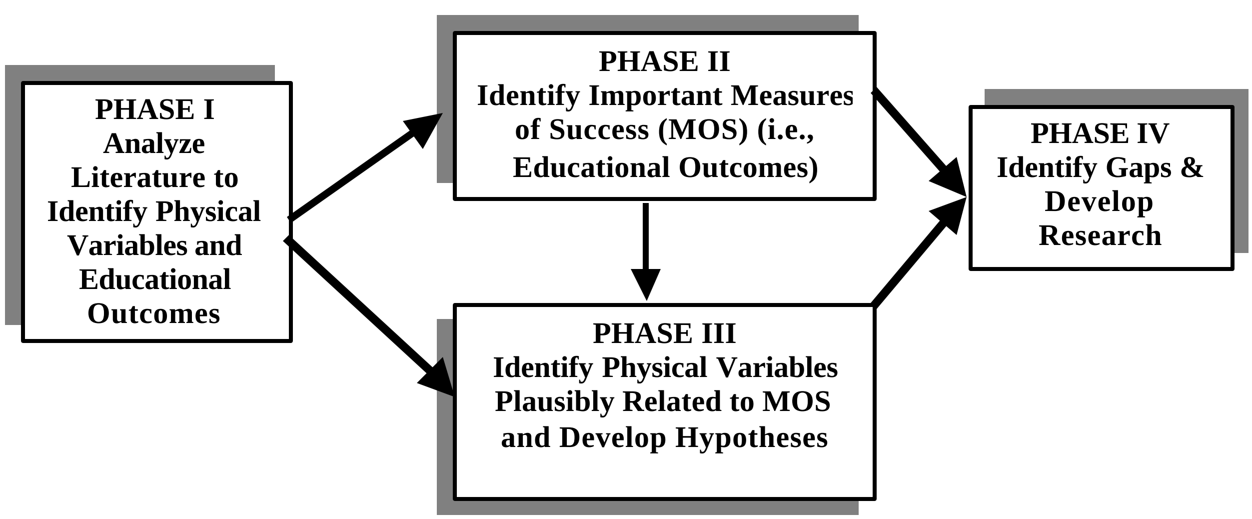


Figure 2.1 Phases of Research

Phase I: Literature Analysis

There were two main purposes for conducting the literature analysis in Phase I: 1) to assess current knowledge regarding the SFE research; and 2) to identify outcome variables and physical factors to seed the brainstorming exercises in Phases II and III. Published studies examining the effects of physical school conditions on students and teachers were derived from the literature in the domains of psychology, environment-behavior, physiology, and others. There were four types of data sources that were utilized: peer-reviewed journal articles; books; doctoral dissertations; and some non-peer reviewed articles or reports. The sources were identified through several means – Internet searches using the Google search engine, Galileo database, the National Clearinghouse for Educational Facilities resource lists (http://www.edfacilities.com), and references cited in the literature obtained.

Since the literature was the source of the variables used to seed the brainstorming lists of outcome variables (Phase II) and physical variables (Phase III), it was important to classify each variable in each study as either an independent (I), dependent (D), or control (C) variable. The independent variables that were related to the physical school environment became part of the preliminary list of physical variables, and the dependent variables that pertained to student outcomes were included in the preliminary list of outcome variables. The literature analysis involved the development of a table in which all variables considered in each study were listed in tabular format using headings shown in the example below (Table 2.1).

Table 2.1. Example of Literature Table Entry

Variable	I/C/D*	How Measured	Relationships to Other Variables	Subjects	Source
Air conditioning	I	Presence or absence: obtained by questionnaire completed by the principals of GA standard schools containing 8th grade.	Higher vocabulary scores in air-conditioned buildings. No significant difference in the composite, reading, language, work-study section and mathematics sections.	8th grade students in 191 public, standard GA schools (per requirements established in the "Standards for Public Schools in GA, 1975)	Chan, T. C. (1980)
Carpet	I	Presence or absence: obtained by questionnaire completed by the principals of GA standard schools containing 8th grade.	No significant relationship with achievement		
Fluorescent lighting	I	Presence or absence: obtained by questionnaire completed by the principals of GA standard schools containing 8th grade.	No significant relationship with achievement		
Interior pastel coloring	I	Presence or absence: obtained by questionnaire completed by the principals of GA standard schools containing 8th grade.	No significant relationship with achievement		
Student achievement	D	Results for 8th grade students' Iowa Test of Basic Skills: vocabulary, composite, reading, language, work-study, mathematics sections	Higher vocabulary scores in air-conditioned buildings.		
Socioeconomic status	C	% of paid pupil participation in school lunch program in the 8th grade			

I=Independent variable, C=Control variable, D=Dependent variable

The variables were typically described by the authors in the "methods" sections of the studies, but they were sometimes only listed in the "findings" sections. The wording used by the authors for each variable was preserved and each variable was listed in its own row as in Table 2.1. Often, the authors stated which variables were independent variables, which were dependent variables, and which variables were controls (e.g., "socioeconomic factors were statistically controlled"). In other instances, this designation had to be inferred based on how the findings were presented. For each variable, the authors also described how it was measured (i.e., operationalized) and this is included in the table under the "How Measured" column as well, with "not specified" indicating where the authors did not describe how a variable was measured. The authors described correlations among variables, typically in the "findings" sections, and these were included in the "Relationship to Other Variables" column. The last two columns in the table are the "Subjects" column in which the number of students, schools, or other unit of measure is indicated and the "Source" column that simply lists the author and date information.

Once the table was prepared, the items to seed the brainstorm lists in Phases II and III were developed. The dependent variables were compiled to develop the original list of "Measures of Student, School, or School District Success" (e.g., student achievement, student behavior) for Phase II. A list of physical variables to seed the brainstorm list for Phase III was developed by compiling the independent variables that were actually some type of physical condition, attribute, or measurement of the school building (e.g., age of the school, and building condition). The literature analysis of the studies evaluated in Phase I is described in detail in Chapter 3.

Phase II: Identifying Measures of Success Using a Concept Mapping Methodology

The purpose of Phase II was for educators (teachers, counselors, principals and assistant principals) to identify educational outcomes (i.e., measures of student, school, or school district success) that they believe are important to monitor or otherwise track. If past and future research does not address the educational outcomes that educators perceive as important, the impact of SFE studies will be reduced. A disconnect between SFE research and educator priorities may reduce the willingness of educators to participate in research, their interest in serving on programming committees for school construction projects, or their interest in doing what they can to create indoor environments that enhance the learning environment. Although there are other school stakeholders who could have been included in this research, such as parents or students, educators were selected for three primary reasons: 1) the awareness educators have regarding educational requirements and other types of outcomes that determine whether or not a student, school, or school district is successful; 2) the difficulty associated with obtaining permission to include students in academic research (adults can sign their own consent forms, whereas students under eighteen years of age cannot); and 3) the convenience of working with a group of educators who meet at a regularly scheduled time for an academic course. Several methods were considered for soliciting required data from the educators in Phase II. These are discussed in the following section.

Comparing Methods

Three methodologies were considered for Phase II – interview surveys, self-report surveys, and concept mapping. Table 2.2 lists some important considerations for selecting the methodology for Phase II.

Table 2.2. Phase II Considerations for Methodology Selection

<table>
<tr><th>Desired Data</th><th>Source of Data</th><th>Attributes of Source</th></tr>
<tr><td>Measures of success</td><td rowspan="3">Educators</td><td rowspan="3">• Difficult to access within their work environment due to busy schedules
• Non-experts with respect to buildings
• Knowledgeable about how parents, teachers and administrators measure “success”
• Difficult to sample representatively due to geographical diversity</td></tr>
<tr><td>Identification of the most important (perceived) measures of success</td></tr>
<tr><td>Categorization of measures of success to provide a common language</td></tr>
</table>

Interview surveys

Interview surveys are widely used in many fields of research, including education and environment-behavior. The interview, like a questionnaire, is one method for obtaining self-report data. In an interview, the researcher directly asks respondents (typically in-person or by telephone) a set of questions and records their responses (Rosenthal & Rosnow, 1991). Large-scale interview studies may require that more than one interviewer be trained to conduct the interviews. If a survey is properly designed and implemented, a completion rate of approximately eighty to eighty-five percent may be expected (Babbie, 1998). According to Babbie (1998), the interviewer must be careful that his or her behavior does not affect the respondent’s perception about questions or the answers he or she provides, be familiar with the questionnaire that is being used, follow the question wording exactly (not necessary for all interviews, but essential for the interview survey), and record responses exactly. When developing the survey instrument, careful consideration must be given to the development of the questions, the specific wording, and even the order of the questions (Rosenthal & Rosnow, 1991).

A well-designed interview survey study could have been used to collect the types of data sought in Phase II; however, more than one interview would have had to be conducted with each interviewee in order to identify measures of student, school, or school district success AND rate the perceived importance of those measures of success. Further, it would not have been possible using the interview survey alone to have the group of educators categorize the measures of success they identified into broader clusters. Accessibility to educators during their workday is difficult to obtain due to their busy schedules, and the time required to interview an appropriate sample would have been much greater than for the other methodologies considered for Phase II. The interview survey technique was not used in Phase II.

Self-administered questionnaire surveys

The questionnaire survey technique is similar to the interview survey method, except that the respondents read the questions and record their answers themselves, without the aid of an interviewer. Less time may be required on the part of the researcher to conduct a questionnaire survey, and a larger sample size is easier to achieve. Questionnaires are usually distributed and collected by mail or electronically through e-mail or a web site, although hand-delivery and pick up is another alternative that may increase the response rate (Babbie, 1998). As with the interview survey tool, a questionnaire must be carefully developed to ensure that the questions do not lead the respondent to produce a biased answer, and some initial pilot testing is recommended to ensure that questions are pertinent and worded appropriately (Rosenthal & Rosnow, 1991).

A questionnaire survey method could have been used to obtain information from educators regarding measures of student, school, or school district success, and their relative importance (using simple statistical analysis). As a precursor to questionnaire development, some other method, such as content analysis of evaluation literature, would have been necessary to ensure that appropriate measures of success were identified and included in the questionnaire. As with the interview surveys, the respondents could not have been involved in creatinge broader categories in which to cluster the measures of success. The disadvantages of using a self-administered questionnaire survey made it an undesirable method for Phase II.

Concept mapping

Concept mapping is defined as "a type of structured conceptualization which can be used by groups to develop a conceptual framework which can guide evaluation or planning" (Trochim, 1989). Using this approach, ideas expressed in the form of statements, such as "teacher retention" or "mathematics achievement," are generated by participants and the relationships among these ideas are represented using multidimensional scaling and cluster analysis, resulting in a relational map showing the relative similarities/dissimilarities of those ideas. The map represents the group-level data generated when participants sort these ideas into categories that make sense to them and rate them according to their relative importance. Typically, the group will interpret the maps and decide how they will be used (Trochim, 1989). The process engages participants using an inductive approach, beginning with specific brainstormed ideas and resulting in the development of broader, more general concepts or categories. Because concept mapping is a structured process with a well-defined beginning and end, the outcome may be achieved in a pre-determined time frame. The tasks for participants are simple to complete and the result is visual and easily understood (Concept Systems Incorporated, 2002).

Concept mapping is most often used for planning and evaluation processes. In evaluation, it may be used to express concepts related to measures or outcomes that are believed to be relevant. An advantage to using this approach is that many different types of concepts can be generated and then sorted into categories – like sorting a pile of apples, oranges, and pears into their own separate baskets. Based on the inherent strengths and weaknesses (Table 2.3) of the three methods considered as they apply to the goals of Phase II, the concept mapping technique was selected.

Table 2.3. Phase II - Comparing Methodology Strengths and Weaknesses

Method	Strengths	Weaknesses
Interview Surveys	• Generally fewer questions left unanswered than questionnaire • Higher response rate typically than questionnaires • Interviewer can make observations about the respondent (if conducted in person) • May be used for descriptive, explanatory and exploratory studies	• Potentially more bias introduced • Can be costly and/or extremely time-consuming • Data entry following interviews may require significant amount of time • Participants are not involved in the analysis and use of data they provide • More than one interview would be required to gather same data as with concept mapping
Questionnaire Surveys	• Less expensive than face-to-face interviews • Can cover a larger geographic area • Larger sample size, typically • Respondents can remain anonymous • Useful for describing characteristics of a large population • May be used for descriptive, explanatory and exploratory studies • May use a service such as FreeOnline Surveys to simplify data collection and analysis	• Often a low response rate • Respondents have no one to clarify confusing questions • Must ask all respondents exactly the same questions • Would require interviews or other method prior to questionnaire development in order to ask appropriate questions • Participants are not involved in the analysis and use of data they provide • More than one questionnaire would be required to gather same data as with concept mapping
Concept Mapping	• Commonly used in planning • Can be conducted in a relatively short time frame • Data acquired from participants in one step are used in following steps • Individual responses remain anonymous to the rest of the group • Software is available to simplify data collection and analysis • Participants are involved in finalizing the names of the clusters generated from their data • Outcomes include agreed-upon cluster names that provide a common language to describe a set of variables	• Smaller sample size than questionnaire surveys, typically • May introduce some bias in the selection of the number of clusters • Works best if participants are gathered together in one place, although this is not necessary

Detailed Description of the Concept Mapping Method

This section provides a detailed overview of the concept mapping method. There are six distinct steps in the concept mapping process (Concept Systems Incorporated, 2002). A brief description of each step is included in Table 2.4.

Table 2.4. Steps in the Concept Mapping Method

Prepare the project	The facilitator (i.e., the researcher) will: • Identify the specific focus of the study (i.e., What will participants be asked to do in order to gather desired data?) and generate the focus statement – the phrase that prompts the brainstorming activity • Develop rating focus statement - a statement and rating scale that guides participants when rating the relative importance of the concepts or ideas that are generated • Identify participants, make initial contact, develop a schedule for completion, and prepare software (if it will be used)
Generate ideas (brainstorming)	• Participants generate ideas related to the focus statement
Structure ideas (sort and rate)	• Participants sort the ideas into piles that make sense to them and rate each idea (typically using a Likert-type scale) regarding its importance, as described by the rating focus statement
Compute maps	• Computer software is typically used to generate a point map, cluster map, point rating map and/or cluster rating map (described below) • Facilitator selects number of clusters to be used
Interpret maps	• Participant group reaches consensus regarding the labels (or titles) for the clusters
Utilize maps	• Participants work with the facilitator to determine how the maps will be used. Examples include examining priorities, developing a structure for a computer database, or creating a strategic plan. For this study, it is the facilitator (i.e., researcher) rather than the participants who used the concept maps. The *data* contained in the point rating map and cluster maps, rather than the maps themselves, were used in latter phases of this research

Types of maps

To better explain the concept mapping process, this section provides an overview of the types of maps that are generated during the process. There are four types of maps that may be created using the concept mapping method (and software). These include the point map, the cluster map, the point rating map, and the cluster rating map.

Point map

The point map is created using the data generated by the participants and represents how often statements were grouped into the same piles or categories. The computer generates a binary symmetric similarity matrix for each individual to identify which statements were sorted together. This consists of a table with as many rows and columns as there are statements (e.g., 100 X 100). In each cell, a 0 is placed where the two statements were not grouped together, and a 1 indicates that they were sorted into the same pile. From this, a group similarity matrix is computed using the combined data. A point map is then computed using multi-dimensional scaling analysis. Each point represents a statement, and the locations of the points on the map represent their similarities (i.e., the closer the points on the map, the more often they were grouped together) (Trochim, 1989). The outcome is a point map in which each point or dot represents a statement, and the nearness of each point to other points on the map represents how often the statements were grouped together by the participants.

Cluster map

The cluster map uses the same data that are input for generating the point map. However, the cluster map shows boundary lines around those points that cluster together based on the data. If software is used, the computer can generate a cluster map for any number of clusters. Cluster analysis is used to group statements on the map into clusters that presumably reflect similar concepts. The Trochim concept mapping process utilizes the X-Y multidimensional scaling coordinate values as input to the cluster analysis in order to achieve clusters that group statements according to their location on the point map (Concept Systems Incorporated, 2002). Trochim (1989) recommends that the facilitator analyze various cluster maps, beginning with a higher number of clusters, and working his or her way down to a smaller number until an appropriate representation (i.e., there is relevant distinction among the clusters) is achieved. Typically, for 100 statements, between 3 and 20 clusters is ideal (Trochim, 1989). The final cluster map is a visual picture of polygons that represent the selected number of clusters. Each cluster contains a set of statements that have been grouped together.

Point or cluster rating map

The point rating map and cluster rating map combine the participant data regarding how to group statements with their Likert-type ratings. These maps illustrate the average importance ratings assigned by the group. The taller the point or cluster shape, the higher the importance assigned. A point rating map looks similar to the point map, except the height of the points represents the average group rating for each item. The cluster rating map looks similar to the cluster map, except the thickness of the polygons represents the average cluster rating (average rating of all statements in each cluster). A more detailed description of how the concept mapping methodology was applied in Phase II is described in Chapter 4.

Phase III: Identifying Physical Factors Plausibly Related to Measures of Success Using a Delphi Method

The purpose of Phase III was to solicit expert judgments of researchers in the SFE field (i.e., those who have studied how school facilities affect educational outcomes) to identify variables that plausibly affect student outcomes identified by educators during Phase II. Although current and past literature sources provide a rich set of physical variables, some of which have been shown to affect outcomes such as achievement, this study addresses the question of whether or not there are other physical factors that have not been studied (or only minimally) that should become part of a set of research priorities for the field to help us better understand how our schools affect students and teachers. Therefore, it is important that this study utilize a methodology that results in a more inclusive generation of variables and some level of consensus regarding this complex problem. A second goal of Phase III was to identify specific hypotheses that SFE researchers perceive to be important to study in the near-term that address the links between physical variables and educational outcomes (i.e., measures of success) that educators perceive to be important.

In Phase III, a group of SFE researchers were asked to identify the physical variables that are most plausibly related to measures of student, school, and school district success, to rate the importance of those physical variables and to form hypotheses for future research. This group is more familiar with findings from past research, areas of weakness in the existing body of literature, and is typically more up to date on current studies. Therefore, SFE researchers are the ideal group to target in this phase of the study. Also, by asking them to consider measures of student, school, or school district success that were rated highly by educators, they were able to develop hypotheses that will be relevant for educators. Table 2.5 lists some important considerations for selecting the methodology for use in Phase III.

Table 2.5. Phase III Considerations for Methodology Selection

<table>
<tr><th>Desired Data</th><th>Source of Data</th><th>Attributes of Source</th></tr>
<tr><td>Physical variables plausibly related to educational outcomes (i.e., measures of success)</td><td rowspan="2">• Researchers experienced with studies regarding school facility effects on educational outcomes</td><td rowspan="2">• Geographically scattered
• Involved in research primarily from an architecture or education perspective
• A relatively small population of researchers</td></tr>
<tr><td>Hypotheses to study in the near-term that include links between physical variables and measures of success</td></tr>
</table>

Comparing Methods

The goals of Phase III can best be accomplished using a method designed for groups. Group techniques are useful because they provide a way for several people to produce a product that is potentially better than what could be produced by individuals alone. They allow efficient use of the time of the participants so that each can contribute without undue burdening. Group techniques also establish commitment from those who participate in the final product that is ultimately produced, and they allow a group to examine social problems that are complex or not well defined (Moore, 1987, p. 18). There are several types of methods for soliciting knowledge from a group of experts or stakeholders. Two of these methods, nominal group technique and the Delphi method, were considered for Phase III, and the Delphi method was selected. Both of these techniques are useful for soliciting individual judgments, combining them, and making decisions (Delbec et al., 1975, p. 4).

Nominal group technique

The nominal group technique (NGT) is used to structure small group meetings and is particularly useful for "identifying problems, exploring solutions, and establishing priorities" (Moore, 1985, p. 24). The objectives of the NGT process have been stated by Delbecq, Van de Ven, and Gustafson (1975, p. 9) as: ensuring that different processes are used during each creative phase; balancing group member participation; and incorporating mathematical voting to aggregate individual judgments. There are four steps that are typically followed when NGT is used: silent generation of ideas in writing where participants independently write down their responses to a question that has been asked; round-robin recording of ideas in which every participant supplies ideas to the group list, one at a time and without discussion; discussion of the ideas to clarify their meanings; and voting on the ideas that are perceived to be the most important and ranking their preferences (Moore, 1985, p. 24).

Delphi method

For this study, the Delphi technique (originally used in forecasting) was chosen to achieve the purpose of Phase III primarily because there is no need for face-to-face contact of participants, unlike nominal group technique or other group methods that require physical proximity (Delbecq, Van de Ven, & Gustafson, 1975). There are several reasons why Delphi is an appropriate method to use for group communication. Among the several listed in Linstone and Turoff (1975), three apply to this particular research: 1) the problem can benefit through subjective and collective judgment; 2) a meeting or meetings of the experts is not feasible due to time and cost restraints; and 3) preservation of heterogeneity rather than the dominance of particularly strong voices is desired. One goal of this study is to begin broad and then narrow the focus based on individual responses to questionnaires, with heterogeneity maintained, particularly in the earlier surveys. Although there were some respondents who voiced stronger opinions than others, all ratings and comments submitted were considered in the analysis of each survey.

The Delphi method typically involves a series of questionnaires given to a group of experts to gain knowledge, opinions or judgments (Moore, 1987). Through the Delphi process, individual responses to each survey are shared through the development of each successive survey, but individual responses usually remain anonymous. Delphi techniques may be used in different types of applications, such as identifying goals, identifying group values, gathering information, educating respondents, or as in the case of this research, establishing priorities. A comparison of NGT and the Delphi method is presented in Table 2.6. This table has been excerpted from Delbecq, Van de Ven and Gustafson (1975, p. 32).

Table 2.6. Comparison of NGT and Delphi Methods

Dimension	NGT	Delphi
Overall methodology	Structured meeting Low variability between decision-making groups	Structured series of questionnaires and feedback reports Low variability between decision panels
Role orientation of groups	Balanced social-emotional and task-instrumental focus	Task-instrumental focus
Relative quantity of ideas	High; independent thinking	High; isolated thinking
Relative quality and specificity of ideas	High quality; high specificity	High quality; high specificity
Normative behavior	Tolerance for noncomformity	Freedom not to conform
Equality of participation	Member equality	Respondent equality in pooling of independent judgments
Methods of conflict resolution	Problem-centered Confrontation and problem solving	Problem-centered Majority rule of pooled independent judgments
Closure to decision process	High closure High felt accomplishment	High closure Medium felt accomplishment
Task motivation	High	Medium

In addition to this comparison, the relative strengths and weaknesses of the two methods (Table 2.7) were considered. The decision to use the Delphi method was dictated primarily by two factors: the geographic distances between participants and the fact that this method typically requires the least time for the participants (although more time for the one conducting the research).

Table 2.7. Phase III - Comparing Methodology Strengths and Weaknesses

Method	Strengths	Weaknesses
Nominal Group Technique	• Group members often enjoy participating • Includes a final vote to bring closure to group activities • Many ideas are generated in a relatively short time period	• Ideas, although more developed than those arising from a brainstorming session, are not fully developed • Requires group members to participate at the same time in the same place
Delphi Technique	• Typically requires less time of participants • Can be conducted with participants geographically scattered • Many ideas are generated in a relatively short time period	• May be time-intensive • The one conducting the research may introduce bias and distort results or impose too many restrictions on the process • Lacks the stimulation of face-to-face contact among group members

In this study, the results of the Delphi process provided important contributions, such as a list of high priority physical variables and a list of hypotheses to be studied in the near-term. These hypotheses form the basis of the recommended research priorities for the field.

Phase IV: Establishing Research Priorities

Phases I through III were designed to provide information necessary to develop research priorities that will, in the long-term, accomplish the following:

- Guide future research in the field by building on the knowledge acquired from the literature, educators, and SFE researchers;
- Ensure that research supports the values of educators;
- Improve the likelihood that money spent on school construction and renovation will create better learning environments.

The selection of research priorities was based entirely on the high priority hypotheses developed by the SFE researchers in Phase III. These priorities are presented in detail in Chapter 6.

This chapter has provided and overview of the methodologies used throughout this study. More specific methodological details for each phase of the study are further described in the following three chapters.

CHAPTER 3

PHASE I - LITERATURE ANALYSIS

Purpose

Researchers from a variety of disciplines have studied the effects of the physical school facility on educational outcomes. Chapter 3 presents a summary of SFE literature, as well as a listing of those studies used specifically to seed the brainstorm lists in Phases II and III of this research (see chapters 4 and 5). The purpose of the literature analysis is three-fold: 1) to identify educational outcomes to seed the brainstorming exercise in Phase II; 2) to identify physical variables that are plausibly related to educational outcomes to seed the brainstorming list used in Phase III; and 3) to identify gaps in current knowledge.

Specific Methodology

The studies analyzed in this chapter represent the literature, as sampled, regarding relationships between physical school conditions (e.g., size, building age, lighting conditions) and educational outcomes (e.g., student achievement, behavior). These studies were identified through various means: Database searches through Galileo, Internet searches using the Google search engine, and primarily by examining the references of the articles and reports obtained. Correlational or causal studies and review articles that could readily be obtained were included in the analysis. Only studies that were conducted in school facilities were evaluated, excluding related studies in which researchers have evaluated the effects of specific types of physical variables on human behavior or performance in other settings. The studies included in this literature analysis evaluated the types of physical variables that have been observed in recent literature reviews (Schneider, 2002; Young et al., 2003), guidance documents that are used for creating high performance schools (Bosch & Pearce, 2003), and the National Clearinghouse for Educational Facilities' *Impact of Facilities on Learning* resource list. The task focused more on acquiring all identified studies regarding ambient conditions (e.g., overall building condition, thermal comfort, indoor air quality), but there was no attempt to accumulate a comprehensive set of studies that examined class size, school size, or open versus traditional plans. There is a large body of research in each of these three areas and a complete review of that literature was outside the scope of this study. Further, an analysis of the selected sample of literature is appropriate for achieving the purposes of this research.

Prior to the analysis of each study, a table was created into which the data were sorted. This table included a column for each of the following: variable (by name); classification as an independent, control, or dependent variable (I/C/D); how measured; relationship with other variables; subjects; and source (as described in Chapter 2). Each variable identified in a study was included in the first column, even though all of the variables were not exactly the type of variable sought for Phases II and III. None were discarded. The determination of whether each variable was considered to be an independent, dependent or control variable was made first by studying how the authors referred to each one of them. When the author did not specify if the variable was an independent, control, or dependent variable, the I/C/D assignment was made based on a somewhat subjective procedure. Often, reading the findings and using common sense often clarified whether a variable was independent or dependent. For example, from the findings that daylighting was correlated with academic achievement, it could be deduced that daylighting was the independent variable (since academic achievement cannot alter the amount of daylight) and that academic achievement was the dependent variable.

This chapter provides a description of literature that was reviewed, as well as a description of how the data were used to identify physical and outcome variables for Phases II and III of this study. The primary outcome of the literature analysis was a table describing each study (Appendix A) and a list of variables for use in the following phases of this research (Tables 3.1 and 3.2).

Summary of Studies Evaluating Links Between Physical Factors and Educational Outcomes

There is increasing evidence that school facilities do affect teacher activities in the classroom and satisfaction, as well as student achievement, behavior, attendance and attitude. The following sections describe a sample of this body of research (chosen as described above). In the original literature analysis, the studies were not sorted into any particular category. However, they have been sorted in this chapter into categories according to type of physical variable to improve readability. The categories include: spatial features; size; building quality/maintenance; visual comfort; thermal comfort; acoustical comfort; indoor air quality; and multiple physical variables.

Spatial Features

What is better for students: open plan classrooms or traditional layouts; spacious classrooms or smaller and more intimate settings? These are types of questions addressed in the studies included in this section. The specific spatial features addressed include interior spaciousness, perimeter structures, and layout (open versus traditional plan). In one study by Ahrentzen and Evans (1984), the impacts of interior spaciousness, perimeter structures (percent of perimeter of classroom with structural walls and open perimeter space), and privacy amenities were investigated with respect to outcome variables including distraction, satisfaction with the classroom environment, teacher restriction of activities to avoid disturbing others, and perceived privacy. The study involved thirteen fourth, fifth and sixth grade teachers (who volunteered to participate and were not randomly selected) and sixty-five students (nine to thirteen years old, randomly selected) from five elementary schools. The findings showed that the interior spaciousness measure of greater ceiling height was correlated with lower visual and kinetic distraction among teachers. Square footage per person was negatively related to kinetic distraction and positively related to classroom satisfaction. For students, a greater ceiling height was associated with reduced visual distraction from student movement and more distraction from physical contacts. Regarding open perimeter space, teachers were more satisfied, restricted activities less often, and were less distracted when there was a large proportion of structural walls. Open perimeter space was associated with less kinetic distraction (distraction from movement of other people) and greater classroom satisfaction, and was not related to restriction of activities. Surprisingly, privacy amenities, such as secluded study space and individual desks, were associated with lower levels of perceived privacy than those without. The authors suggest that this may be related to limited access to use them. Perhaps the most appealing aspects of this study are the measures of openness that were used. Rather than categorize classroom as "open" or "traditional," the study utilized very specific measures of interior spaciousness and percentage of various types of perimeter structures (e.g., permanent walls, open entrance space). It is this type of specificity in operationalization that must be developed for physical variables in the SFE field in order to consistently characterize learning spaces.

Open plan versus traditional school design was the focus of a study by Cotterell (1984). In this study, 142 intake students from four suburban high schools in two open plan and two conventionally designed schools were evaluated. Teachers in an open plan school were more likely to follow lecture with group work rather than to follow it with seatwork. In the open plan schools, transitions between activities occurred more frequently and lasted for a longer period of time than in the conventional school. There were also higher incidences of off-task behavior and peer-related interactions in the open plan schools. Students in the open plan schools experienced less anxiety about locating classrooms and were less unclear about school procedures; however, they experienced greater schoolwork anxiety and were more anxious about their performance in front of other students. Unlike the Ahrentzen and Evans (1984) study, this one characterizes schools as being open plan or conventional.

To summarize, measures of openness in a classroom environment have been associated (positively or negatively) with distraction, teacher restriction of activities, satisfaction, off-task behavior, anxiety, and peer-related interactions.

Size

There are many studies that have evaluated the links between school size and a host of student outcomes – academic, social, and behavioral. In her review article, Cotton (1996) examined sixty-nine documents and concluded that academic achievement is equal or superior in small schools when compared to large schools. Student attitudes and social behavior (violence, theft, substance abuse, gang participation, and truancy) were generally more positive in small schools, as was student attendance. Small schools have a lower drop out rate than large schools and students in small schools have a greater sense of belonging. The benefits of small schools (academic, attitudinal, and behavioral) were greater for minority and poorer students. Regarding college-related outcomes (entrance exam scores, grade point average, acceptance rates, attendance, and completion), there were no differences between small and large schools. A review of the literature regarding secondary school size and student outcomes was conducted by Fowler (1995). Student outcome variables examined included student attitudes, student achievement (e.g., test scores, constructive employment, college attendance, and grade point average), voluntary participation in extracurricular activities, and enduring effects (e.g., participation in college extracurricular activities, adult voluntary participation). He concluded that student attitudes, attendance, achievement and voluntary participation were adversely affected in large schools with a graduating class greater than 750 students. Some studies even suggested that the effects may continue through adulthood. The least robust correlations, based on the studies he reviewed, were the effects on academic achievement, as there were the fewest studies supporting this relationship and there were contradictory findings. In spite of the support of smaller secondary schools, the trend in the past many years has been to consolidate and build larger high schools.

Individual school size and school district size and their relationship with academic achievement were the focus of a study by Johnson, Howley, and Howley (2002). The study examined the relationships between school (and district) size and student scores on two different standardized tests – Stanford Achievement Test 9 at grades five, seven and ten (reported as mean percentile ranks for total performance on all subtests) and the

Arkansas Benchmark Test for grades four and eight. Smaller school size, especially among lower socioeconomic groups, was correlated with higher academic achievement. The number of students or schools was not specified, but the study included all Arkansas schools. Although the study did not state the exact sample size, it is presumably quite large.

In a study involving 293 secondary schools, significant relationships were found between several independent variables and outcome measures, according to Fowler and Walberg (1991). Among those, total school enrollment for all grades was negatively associated with six outcome measures: percent passing reading (Minimum Basic Skills Test); average mathematics test score (High School Proficiency Test); average writing test multiple choice score (High School Proficiency Test); percent passing math (High School Proficiency Test); and percent of students influenced by school and retained. Several achievement test scores and retentions were higher in smaller schools. This study is particularly interesting because of the large number of independent and control variables (school, school district and teacher characteristics) included. The study supports previous research regarding academic achievement, although proponents of larger schools are likely to list cost effectiveness and a more extensive curriculum as reasons to build bigger schools.

School size and class size are two of the independent variables studied in relation to school connectedness (i.e., students feel cared for and feel like a part of their school) in a study by McNeely et al. (2002) that included 71,515 students in 127 schools. The other independent variables included: public versus private; urbanicity; percentage of students participating in extracurricular activities; classroom management climate; discipline policies; teacher qualifications; and demographics. There was a weak relationship between school size and school connectedness (larger school – decreased school connectedness). There was no significant relationship between class size and school connectedness.

By analyzing twenty-two case studies, Nathan and Febey (2001) showed how some school systems have utilized research regarding school size to develop smaller school. The authors conclude that these smaller schools provide a safer, more positive and challenging environment than large schools, fewer discipline problems, and higher academic achievement, graduation rates, and satisfaction among families, students and teachers.

In summary, smaller schools have some significant advantages over large ones, particularly with respect to attitudes and behavior, with weaker evidence to support improved academic achievement (which is higher among impoverished and minority students) and school connectedness. However, support for larger school facilities is still prevalent among decision-makers.

Building Quality/Maintenance

If a school building is poorly maintained, science equipment is scarce, and needed renovations have not been made, how are students and teachers affected? Do teachers in such buildings feel less valued than their peers in newer or better quality school facilities? Do students in the higher quality facilities perform better academically? These types of questions have been explored by a number of researchers. In 2001, school systems spent $26.8 billion on construction, with fifty-eight percent of that going towards additions and modernizations (Agron, 2002). Deferred maintenance is believed to affect health and safety, student and staff morale, and student learning (Lawrence, 2003). There have been several studies that have evaluated the effects of overall building condition, quality, or maintenance and its effects on student outcomes, eight of which are described below.

Building age has been shown in more than one study to be associated with student outcome variables. In one example, Chan (1982) found that students (n=119) in a newer school had more positive attitudes about their school than students in the control group housed in an older building (n=96), but this study did not attempt to measure academic performance.

In a study of 280 fourth and sixth grade students, those attending a newer school had higher achievement in math, reading, listening and language than those enrolled in an older, “less desirable” facility (Bowers & Burkett, 1987). The specific scores used to evaluate achievement were not specified. Similar socioeconomic status was assumed. In addition to improving achievement, Bowers also found that fewer major health problems were reported, fewer disciplinary actions were taken, and attendance was higher in the new school. Researchers recognize that the study is limited because the two schools were not randomly selected, both are located in Upper East Tennessee, and students were not matched for levels of achievement from one school to the other.

In a study involving forty-seven small, rural high schools in Virginia, student achievement was also shown to be higher in schools with better physical conditions (Cash, 1993), using scores of the Test of Academic Proficiency for 11^{th} graders. Physical building conditions were based on the Commonwealth Assessment of Physical Environment. Science scores were associated with schools with better science laboratory facilities. Structural conditions had less of an impact on student achievement than cosmetic conditions. Surprisingly, the number of student disciplinary actions were higher in the schools in better condition. Limitations of the study have been identified by the researcher, including some confusion with specific questions used in the data collection tools and a lack of variance within the school sample.

The impact of the physical environment on student affective performance (which includes self-concept, attitudes towards peers, attitudes toward teachers, self-efficacy of learning, feeling of homework overload, and intention to drop out of school) was evaluated by Cheng (1994). Higher quality physical environments (rated according to student perceptions based on eleven items) positively correlated with all measures of student affective performance (including student attitudes about their schools), with the exception of self-concept.

A study of 120 schools ranging in size from sixty-five to 1200 students found that students in the above standard schools buildings (using the evaluation tool described below) had higher achievement scores (as measured by scores of the Comprehensive Test of Basic Skills test administered to 11^{th} graders in the Spring) when compared with students in substandard buildings (Earthman, Cash, & Van Berkum, 1995). Principals responded to an evaluation instrument that asked about the presence or absence of twenty-nine items in three categories (building condition, cosmetic condition, and structural condition). This information was used to classify schools as above standard (top twenty-five percent) and below standard (bottom twenty-five percent). In five categories (building age, air conditioning in the classroom, noise, exterior painting, and site acreage), student scores were actually higher in the substandard buildings (no probable reasons were suggested). Although the number of reported disciplinary incidents per pupil was small in both the above standard and substandard schools, there were fewer incidents reported in the above standard schools when cosmetic and overall conditions were compared. However, when structural conditions were compared, the above standard schools reported more disciplinary incidents, although the reasons for this are unclear.

Another study that compared student academic achievement (Wisconsin Student Assessment System scores) and building condition (using the 1991 Construction Control Corporation scores), Lewis (2001) found a number of significant relationships (eleven out of thirty-six tested) between facility condition and student achievement using multiple regression, although the findings were not completely consistent across the years studied or across different test areas. These significant relationships include those between the Existing Conditions Total score (ECTOTZ) and mathematics (1996), ECTOTZ and science (1996), Existing Conditions Adjusted (ECADJZ) and mathematics (1996), Educational Adequacy Total (EATOTZ) and mathematics (1996), EATOTZ and social studies (1996), ECTOTZ and science (1997), ECTOTZ and social studies (1997), ECADJZ and language (1997), ECADJZ and science (1997), ECADJZ and social studies (1997), and CATOTZ and science (1997). There were no significant relationships for the 1998 school year. Some of the inconsistency may be due to the time gap between facility scores and student test data. When the influence of student variables were statistically controlled, the facility measures explained approximately ten to fifteen percent of the difference in student scores across schools. The methods used in this study have been criticized by other SFE researchers.

Renovations were used as a measure of building condition in a study conducted by Maxwell (1999) in twenty-one elementary schools. If a school had undergone a major renovation in the previous ten years, the school was considered "recently renovated." Using scores of the Pupil Evaluation Program test for 3rd and 6th graders from the 1982-1983 through the 1996-1997 school years, she found that math scores were significantly related to the percentage of students attending a recently renovated school, with the effect stronger for sixth graders. Although there was not a significant correlation with improved reading scores, this is perhaps attributable to the fact that there was an influx in the proportion of students who were non-native English speakers. One limitation of this study is the relatively small sample size of only twenty-one schools. The author recommends future research that includes a larger sample size that would use methods to assess causality of the links between building improvements and student achievement.

The relationship between parental involvement on the condition of school facilities in Washington D.C. and the impact of those variables and student achievement (as measured by the Comprehensive Tests of Basic Skills) was the focus of a study by Edwards (1991). Two models were tested, both using a larger data set for which some data were missing and a smaller subset of fifty-two schools for which more data were available. The findings support the hypotheses that parental involvement (as determined by the Parent Teachers Association budget per pupil) is associated with better school building conditions and that better building condition is associated with higher student test scores. Although higher school enrollment was associated with better building condition, it was also related to lower student achievement. Elementary schools tended to be in better condition than junior high or high schools, and wealthier, more predominantly white schools had higher student achievement. The author stated that possible misspecification of the two models used is a concern, although it is impossible to know for certain whether a model has or has not been correctly specified. The validity of using the Parent Teachers Association budget per pupil as an indicator of parental involvement has not been tested.

The studies analyzed here indicate that good school condition is generally associated with benefits for students (such as improved academic achievement) when compared with their counterparts housed in schools of poor quality, although some studies showed significant relationships between better conditions and undesirable outcomes (e.g., Cash showed a higher rate of disciplinary actions in the schools in better condition). Although it is unlikely that high-tech, extravagant building features are unnecessary to ensure that school environments enhance learning and other desirable outcomes, there is currently no way to characterize "good enough". There remains work to be done to characterize building condition and a need to refine methods used to test relationships between building condition (and maintenance) and educational outcomes.

Visual Comfort

Without sufficient and appropriate lighting, students are apt to have difficulties reading in the classroom and may experience other types of visual discomfort, leading to reduced academic performance and modified behavioral response. A review of ten lighting studies by McGuffey (1982) demonstrated that there are significant relationships between visibility and visual performance. Based on his review of the lighting literature, Fletcher (1983) concluded, "lighting does seem to have some effect on children's behavior, cognitive performance, visual fatigue, and possibly health." In a third review of the lighting literature, Dunn et al. (1985) recommended that it is important to identify students' preferences for illumination and that teachers should try to create both well-lit and dimly lit areas in the classroom and encourage students to sit where they are most comfortable.

The relationship between different types of school lighting and their effects on physical development and student performance was studied by Hathaway (1995). The study was conducted at five sites in various numbers of classrooms (two to four at each site). The first was lit with indirect high-pressure sodium vapor lamps, the second was lit with full-spectrum fluorescent lamps, the third and fourth sites were lit with full-spectrum fluorescent lamps with supplemental ultra-violet (UV) lights (Vita-Lites), and the fifth site was lit with cool-white fluorescent lamps. The study involved a total of 327 fourth grade students during the 1988-1989 school year, although only 233 completed the study. There were no significant differences found in the sex, age, daily nutrition, or academic achievement among students at each of the five schools. The students in classrooms with the supplemental UV light gad fewer dental caries than those in the non-UV groups, one-fifth as many when students with fissure sealants were excluded from the analysis. The sites with full-spectrum lighting (sites 2, 3, and 4) had significantly better attendance (approximately 3.2 days per year) than the other sites. Based on scores of the Canadian Test of Basic Skills, the students in classrooms lit by full-spectrum lighting made the most rapid progress between pre- and post-tests, followed by those in the classrooms with cool-white fluorescent lights. Those in the classrooms lit by the high pressure sodium vapor lamps fell significantly behind the others.

In recent years, the use of daylighting in schools has received a great deal of attention. Anecdotally speaking, there are many who argue that natural light and the ability to know what outdoor conditions are like is "good for the soul," but one very important daylighting study (Heschong Mahone Group, 1999) has brought scientific rigor to this topic that was often missing in the past. Students with more daylighting progressed twenty percent faster (rate of improvement over a one-year period) on math tests and twenty-six percent on reading tests in one year. Those with the greater window area progressed fifteen percent faster in math and twenty-three percent faster in reading than those with the least. Well designed skylights that diffuse light effectively were also related to more rapid progress on test scores. Additionally, students in classrooms in which windows were operable also progressed more quickly than those with inoperable windows. Test scores in math and reading were used for 21,000 students from three school districts, including Orange County, CA, Seattle, WA, and Fort Collins, CO to measure achievement. These scores were compared to lighting variables, such as window size, tint, presence and type of skylights, and the amount of anticipated daylight. A reanalysis of the data (Heschong et al., 2002) has supported the findings from the earlier study.

Other studies have focused on the effects of various types of electric lighting. For example, the impact of different types of electric lighting on student behavior was the focus of a study by Ott (1976). The behaviors of first grade children in four windowless classrooms were observed. Standard cool-white fluorescent lighting with solid plastic diffusers provided illumination in two of the classrooms while the others used full-spectrum fluorescent tubes with lead foil to shield the ends of the tubes to reduce X radiation exposure. Cameras mounted in each classroom (not in view of the children) photographed time-lapse sequences of photos during the school day. The behavior of hyperactive children in the rooms with full-spectrum, shielded lighting was better than the children in the standard classrooms. Children in the room with standard lighting were described as being more fidgety and were observed “leaping from their seats, flailing their arms, and paying little attention to their teachers,” while those with full-spectrum lighting were less nervous and paid more attention to the teacher. The sample size in this study was small, but perhaps necessary to conduct the types of observations that were done.

Student behavior was also the focus of a study that compared white walls and cool-white fluorescent lighting, common in school facilities, with blue walls and full-spectrum lighting (Grangaard, 1995). Off-task behavior and mean blood pressure were measured for five six-year old boys and six six-year old girls (a very small sample) in a public school during three phases of the study (before modification, during and after the classroom was returned to its original condition). A decrease of twenty-two percent in off-task behaviors was observed in the room with the blue walls and full-spectrum lighting and student mean blood pressure was nine percent lower. The sample size in this study was quite small and therefore the generalizability of the findings is questionable.

There is evidence supporting the notion that lighting variables do contribute to various types of student responses, including academic achievement and behavior. Prior to the 1950’s, natural lighting was the predominant means of lighting in schools (Benya, 2001). Electrical lighting later became the most important means of illumination, but once again the use of natural lighting is becoming a popular choice for satisfying a large portion of the lighting requirements. Designers are challenged with providing just the right combination of natural and electric illumination to provide sufficient lighting with glare control, and researchers are faced with the challenge of understanding how lighting variables affect student and teacher performance.

Thermal Comfort

Researchers generally agree that temperature and humidity levels within a comfortable range are necessary for optimal student and teacher response, although preferences vary according to age and gender. However, there is still a large number of schools lacking air conditioning, even in climates that reach uncomfortably warm temperatures during the school year. The effects of the presence or absence of air conditioning on academic achievement was one of the interior conditions evaluated by Chan (1980). The effects of air conditioning, carpet, fluorescent lighting and interior pastel wall color on scores on the Iowa Test of Basic Skills were studied for eighth grade students from 191 public schools in Georgia. Only air conditioning was shown to improve test scores in vocabulary. No differences were observed for the composite, reading, language, work-study and mathematics sections of the test. Fluorescent lights, carpeting or pastel coloring did not significantly affect test scores.

Green (1974) reviewed three studies that examined the relationship between relative humidity and absenteeism. One study involving schools showed reduced absenteeism when humidification was supplied during the heating season. In this study by Ritzel in (1966 cited in Green, 1974, in German), half of the 210 Kindergarten students in Switzerland involved in the study were in pavilions without artificial humidification and the other half in pavilions with humidification supplied. Average room temperature and average relative humidity were recorded. The findings showed that attendance rates in the humidified spaces (forty-nine percent relative humidity) were better (three percent days absent) than those without artificial humidification (nearly six percent days absent) in which the relative humidity averaged forty percent.

In his review, Schneider (2002) cited several studies supporting the notion that when temperatures and humidity levels are in the moderate range (68-74 °F and 40-70%, respectively) students are best able to perform mental tasks. Similarly, McGuffey (1982) concluded, after reviewing nine studies, that thermal conditions do have significant effects on academic achievement (although some studies he reviewed were somewhat limited in their generalizability). Schneider (2002) reported that Harner (1974) demonstrated that temperatures between 68-74 °F were best for learning reading and math. There has been a relatively sparse amount of research focusing on the effects of the thermal environment on students and teachers in recent years, perhaps because school designers today strive to achieve comfortable temperatures and humidity ranges in all schools.

Acoustical Comfort

Classroom acoustics have been shown to affect educational outcomes. As stated by Schneider (2002) in his review, "clearly, classroom acoustics matter." He cites studies demonstrating links between acoustical conditions to spelling and reading ability, behavior, attention, concentration, blood pressure, feelings of helplessness, and a lack of persistence on tasks. McGuffey (1982) also noted that each of the seven studies he reviewed concerning noise and student achievement showed significant relationships.

Associations between reading ability and noise exposure in elementary school children have been shown in multiple studies. In Evans & Maxwell (1997), 116 first and second grade students in two elementary schools (predominantly African-American) in New York City were evaluated to determine if language acquisition acts as a mediator between noise exposure and reading deficits, and whether short or long-term exposure contributes to reading problems. Chronic noise exposure, rather than acute exposure, was correlated with reading deficits. Speech perception, rather than sound perception, acted as a partial mediator.

In one study, 156 students were asked to perform sixty visually presented tasks from the Standard Progressive Matrices, 1938 version, a type of intelligence test, in either a noisy environment (70 dbA) or a quiet environment (40 dbA) (Christie and Glickman, 1980). The findings indicated that boys performed complicated problems better in a noisy environment, while girls performed higher in a quiet environment.

The effects of classroom noise, specifically "task-overlapping linguistic noise (ambient noise including conversations)," on hyperactive children were studied by Zentall and Shaw (1980). This study included twenty-four hyperactive children (three female and twenty-one male) and twenty-four controls (six female and eighteen male). In the first experiment, hyperactive children were more active in the higher-noise condition when compared with the more noisy condition, but the control children were more active during the low-noise condition. The hyperactive children performed worse on the problem solving tasks in the noisy environment versus the low-noise condition, but the reverse was true for the control children. In the second experiment, twelve of the original subjects were unavailable for testing and four new children were added to the sample.

The noise was presented through speakers in the room, rather than earphones (as in experiment 1), and the task was presented in a new format and tested reading rather than math skills. Hyperactive children had higher rates of commission errors under the high-noise condition versus the low-noise condition. There was some indication that high levels of noise were more disruptive when the required tasks was unfamiliar, but less so for familiar tasks.

In a review of seven studies that examined acoustics and student performance by McGuffey (1982), all showed significant relationships. Six of those studies demonstrated that unwanted noise adversely affected student performance, while the seventh one showed that desirable music was associated with an increase in test scores in reading comprehension in fifty-eight percent of the sample. The review by Earthman and Lemasters (1998) stated that excessive noise was associated with student stress, dissatisfaction with the classroom, and lower achievement. Based on the studies reviewed, excessive noise may hinder teacher and student outcomes, but the effects are plausibly moderated by gender and other factors (such as hyperactivity). Acoustics are an important piece of the school design puzzle, but there is still a lack of understanding about how different acoustical conditions affect various sub-groups in the population.

Indoor Air Quality

Indoor air quality (IAQ) is one important physical condition that is receiving much attention. One in five school buildings are reported to have IAQ problems (U.S. General Accounting Office, 1996). In a study conducted by the National Center for Education Statistics, eighteen percent of schools responding reported unsatisfactory indoor air quality conditions and twenty-six percent reported poor ventilation (Lewis et al., 2000). An estimated twenty percent of school absenteeism in both elementary and high schools is due to asthma, an illness that is exacerbated by indoor pollutants (Richards 1986, cited in Bayer et. al. 1999). Indoor air pollutants most often measured in schools are formaldehyde, volatile organic compounds, carbon dioxide, and aerosolized microorganisms (bioaerosols). There is evidence to suggest that biological contaminants (e.g., allergens and molds) cause symptoms reported in schools for which complaints regarding IAQ were high. Formaldehyde levels generally fall below the threshold level of 0.05 ppm. Little data exists on the impacts of indoor VOCs and aldehydes, but these are suspected of causing adverse health effects on building occupants (Daisey & Angell, 1998). With regard to indoor air quality in schools, significant building-related problems include inadequate ventilation and water damage (Bayer et al., 1999) that can lead to problems with mold. In spite of the challenges of maintaining healthy school environments, Bayer et al. (1999) states, "there have been few good scientific statistically sound studies of school IAQ and its impact on the learning ability of students."

A study conducted by Righi et al. (2002) in four university libraries combined physical monitoring of indoor pollutants (dust, formaldehyde and other volatile organic compounds) and occupant surveys. The study did not identify environmental problems related to sick building syndrome among users of the libraries. Library users in reading rooms completed questionnaires on the day that physical monitoring was conducted. A total of 130 questionnaires were collected. The survey asked for general information about the occupant (sex, age, education and occupation), library attendance (frequency, average time daily, time of day most often using library), possible discomfort (ventilation, humidity, light, heat, cold, noise and bad odor), and symptoms related to sick building syndrome (coughing, nausea, headaches, watery eyes, dry skin, and whether onset occurs in library or irrespective of using the reading room). The researchers found that self-reported symptoms of sick building syndrome occurred more frequently in the library in which occupants perceived that the environmental conditions were the most uncomfortable. However, recorded measurements of microclimatic conditions were not correlated with self-report symptoms. The study recommended that further study is warranted due to the fact that total dust concentrations and total volatile organic compound concentrations were near or exceeded guideline values.

With the increase of health conditions such as asthma and parental concerns about the links between indoor air quality and health, research in this area is likely to increase. Litigation has also been a driving force that has emphasized the need for more information. It is not uncommon to hear teachers complain about the quality of the air inside their schools, particularly those in portable classrooms where ventilation is sometimes inadequate. Increasingly, school personnel are seeking out resources such as the Environmental Protection Agency's *Tools for Schools* package to help them identify and solve common problems that contribute to poor indoor air quality in their facilities.

Multiple Physical Variables

Several other studies were reviewed in which multiple physical variables were evaluated with respect to their effects on educational outcomes. In one study, a survey methodology was used to evaluate the impact of deteriorating school facilities and overcrowding on teaching and learning in five specific areas: lost instructional time due to facility-related problems; diminished teaching and learning effectiveness due to facility conditions; reduced options for the curriculum, state and federal facility requirements;

and student health and safety as it pertains to the school facility (Duke and Griesdorn, 1998). A four-page survey was sent to each Virginia school superintendent, with 128 responding (ninety-six percent). Out of those 128 school districts, approximately thirty percent closed at least one school because of facility-related problems and early dismissals were necessary at least forty-four other times (often due to the lack of air conditioning on very warm days). In addition to air-conditioning and other mechanical system problems, electrical and wiring, and water and sewer problems were reasons for closure or early dismissal. Superintendents in Virginia also faced other facility-related challenges. Because of a shortage of space, sixty-three percent of the school districts reported holding classes in areas not intended for instructional purposes (e.g., auditoriums, cafeterias, storage areas, book closets), sometimes eliminating the use of those spaces for important instructional support activities. Mobile units, not necessarily a desirable solution, have been leased or purchased by a large number of school districts as well. The limited space has also resulted in approximately twenty percent of the districts canceling or eliminating certain courses, often vocational education and elective classes, because there was simply nowhere to hold them. Additionally, federal and state mandates pressure school districts to increase their classroom space. More than seventy percent of the respondents indicated that the number of classrooms should be increased to meet those requirements. Approximately seven percent of the superintendents reported that problems with facilities resulted in student injuries or absenteeism.

The links between thirty-nine design patterns (e.g., quiet areas, intimacy gradients, and lunchroom atmosphere) and composite percentile rankings of student scores on the Iowa Test of Basic Skills (ITBS) for Reading and Math were investigated by Tanner

(2000). The design patterns were evaluated using an instrument designed by the author. Using this instrument, evaluators assigned values “representing the degree to which each pattern was perceived to be present.” The larger population included forty-four elementary schools (22,679 students) in thirteen different school districts in Georgia. The sample included only the upper twenty percent and lower twenty percent of the schools, based on fifth grade composite reading and mathematics scores for the 1996-1997 school year (two others were dropped), leaving a total of fourteen schools in the final analysis. A correlation analysis revealed that seven design patterns were positively and significantly correlated with the ITBS scores. These include context (school and grounds compatible with surroundings), outdoor rooms (learning environments located in the beauty of nature), pathways (clearly defined areas that “allow freedom of movement among structures”), outdoor spaces (outdoor places designed using trees, fences, wings of buildings, walkways, etc.), technology for students, technology for teachers and overall impression (whether the environment is student and teacher friendly and meets education program needs). Regression analysis showed that four of these actually predict ITBS scores (technology for teachers, pathways, overall impression, and positive outdoor spaces). The scoring instrument used to determine a design score per pattern has been shown to have a test-retest reliability of 0.82 and the reliability coefficient for the study sample was calculated to be 0.90 (Cronbach’s alpha). The greatest limitation of this study was the sample size of fourteen schools in the final analysis. Replications with a larger sample size may strengthen the findings.

Several types of physical variables were shown to be associated with student achievement in a study by O’Neil and Oates (2000). They investigated the effects of school facilities in seventy central Texas middle schools on student achievement, behavior, attendance and teacher turnover rates. There were significant differences in four measures of student achievement between the top and bottom twenty-five percent, as rated using the Total Learning Environment Assessment (TLEA) total score. This assessment contains eighty-two items using a four-point Likert scale and was based primarily on the Guide for School Facility Appraisal (Hawkins and Lilly, 1998). The educational outcome variables evaluated in this study included: percentage passing reading; percentage passing math; percentage passing all sections; and percentage passing reading, writing, and math. No significant differences in student behavior, student attendance, or teacher turnover rate were observed. Regarding subsections of the TLEA, building age had the strongest relationship with achievement. The subsection "academic learning space" was positively related to three measures of achievement (percentage of eighth graders passing reading, math, and three subjects – reading, math, and writing) and the subsection "exterior environment" was positively correlated with a percentage of eighth graders passing all sections. There were fifteen questions on the TLEA that were significantly correlated with measures of student achievement. Some of the types of variables included in those question were: noise, availability of technology and internet/intranet utilization, size and design of specialized learning areas, the extent to which teachers are permitted to function as professionals, roof leaks, and carpeting (direction of correlations not specified at the question level).

Reviews of research have also provided some conclusions regarding how the physical school environment affects educational outcomes. In her review, Weinstein (1979) concluded that design factors, including furniture arrangement, affect students' general behavior and attitudes, but that effects on academic achievement had not been shown. Her review was primarily focused on open space versus more traditional classrooms. One of her findings was that a number of undesirable outcomes (e.g., dissatisfaction, nervousness, less social interaction) occur when there are crowding conditions, but that the effects on achievement were unclear. She noted that noise is a variable for which she stated that there have been too few realistic studies to conclude whether it affects academic achievement, but other acoustics studies have since been conducted. Windowless classroom studies she reviewed did not support the idea that students can concentrate better in them or that they contribute to psychological or physical harm.

In his review, McGuffey addressed outcome measures including student achievement, performance, and self-concept. The author used a "counting approach" to summarize his findings, meaning that he tallied the number of studies that showed correlations among variables and gave equal weight to each study, recognizing the weakness of doing so. McGuffey stated two main conclusions based on his review: "(1) obsolete and inadequate school facilities detract from the learning process; modern, controlled physical environments enhance it, and (2) facilities may have a differential impact on the performance of pupils in different grades and for different subjects." More specifically, he demonstrated that building age, thermal factors, seeing factors, color and interior painting, hearing factors, open space (particularly regarding non-cognitive outcomes), site size, building maintenance, and special instructional facilities (science labs) were associated with educational outcomes, although not all of the studies in each category showed significant results. He also found very mixed results or a lack of significant relationships among amount of space, windowless facilities, underground facilities, or building utilization and educational outcomes.

Earthman and Lemasters (1998) summarized the findings from Lemasters' doctoral dissertation that synthesized studies regarding school facilities and student achievement and behavior. She found that newer schools were associated with higher student achievement, fewer disciplinary incidents, better attendance and a more favorable social climate. Better facility condition has been associated with higher achievement scores, more positive student attitudes (in response to more stimulating environments), and better science achievement (with better science labs). Air conditioned schools and facilities that "allow for individual preferences for heat" were also associated with higher achievement. Interior color, particularly pastel wall color, was related to reduced blood pressure and higher student achievement. External noise has been shown to cause student stress, student dissatisfaction with their classroom, and lower student achievement. Lighting variables have also been shown to affect student achievement, attendance, and blood pressure. Regarding classroom density, overcrowding predicted task inattention and negatively affected student achievement in lower income schools. Students are often uncomfortable in areas where there is little privacy, and they experienced more anxiety in open-plan classrooms.

There are several studies that have evaluated the effects of spending on educational outcomes. One of those conducted by Wenglinsky (1997) evaluated the effect of school expenditures on a variety of outcomes. There has been an ongoing debate over the past 30 years or so as to what types of expenditures affect student performance or if it has any effect at all. In this study, a nationally representative sample (number not specified) of 4th and 8th grader mathematics achievement scores (National Assessment of Educational Progress scores) was evaluated against a set of other independent variables. For 4th graders, higher expenditures on instruction and school district administration were related to increased teacher-student ratios. These increased ratios raised average math achievement. For 8th graders, higher expenditures on instruction and school district administration increased teacher-student ratios, resulting in reduced problem behaviors. Also, an improvement in the school's social environment, reduced problem behaviors, and a more positive social environment were associated with improved average math achievement.

Discussion

The literature analysis has presented evidence that characteristics of the physical school environment do affect student and teacher health, behavior, attitudes, achievement and other outcomes. However, for each type of physical variable (or set of multiple variables), there is still a great deal that is not understood about *how* the physical environment contributes to or hinders specific outcomes. In fact, only one of the studies reviewed (Evans and Maxwell, 1997) identified a partial mediator to explain *how* aircraft noise affected reading skills (by interfering with speech perception rather than sound perception). This is no surprise, however, based on the fact that there is still so much information lacking even about what physical variables affect which outcomes. One could argue that now is the time to delve into the how question for those relationships about which there is general agreement – such as thermal conditions and achievement, overall building condition and achievement, and science labs and science achievement. On the other hand perhaps it is enough to know that schools must provide comfortable thermal conditions, be well maintained and modernized, and provide good science labs in order to enhance academic achievement. The primary factor preventing this from occurring likely a lack of funding to ensure that they are provided.

Another consideration about the studies reviewed is that they vary in their scientific rigor. In many cases the sample size is very small and almost none of them attempt to show causality, for various reasons. There are many inherent difficulties in showing causality when there are numerous variables that are outside the control of the investigator. Perhaps one of the more scientifically rigorous studies to date was conducted by the Heschong Mahone Group (1999), and yet, it has been criticized for not including some evaluation of teacher quality (a difficult construct to operationalize adequately). A reanalysis of the data in 2002 confirmed earlier findings. Time and money will always limit one's ability to conduct a "perfect" study. Yet, perhaps there are overlooked but important variables to consider when trying to understand links between the school environment and learning or behavior, such as teacher quality, teacher classroom management style, or disciplinary policies. One example of a study that included some interesting teacher variables was by Fowler and Walberg (1991) that considered teacher's average salary, total number of teachers in the school, teacher's highest degree earned, and average number of years of experience (in the school, district, state, and in education). Only average salary and percentage holding a Bachelor's degree were related to any of the outcome variables.

The majority of the studies reviewed focus on the outcome measure of academic achievement (particularly math and reading), measured using several different types of standardized tests. Other outcomes that have received the most attention include attitudes (student and teacher) and behavior. Therefore, while there may be convincing evidence of the links between a particular physical variable and a specific outcome (e.g., daylighting and academic achievement), there is little to no research available regarding the effects of that particular physical variable on other types of outcome measures (e.g., mood). Perhaps other types of "outcomes," such as mood, may really be mediators of other effects. The identification of other important outcome measures (as perceived by educators) is the primary focus of Phase II of this study.

The question of whether or not researchers have, in the past, studied the most significant physical variables remains to be answered. For example, the provision of individual, accessible offices for teachers may help them feel more valued as professionals, allow them to spend one-on-one time with students who need additional help, or provide them with much needed space to store books and materials to help them perform their job better. However, no studies were identified that explore the effects of the presence of faculty offices on teacher attitude or student achievement. Is the provision of faculty offices more or less important than supplying appropriate daylight to the classroom? Many questions remain to be answered. In the literature reviewed, most examined overall building condition, building age, and school enrollment. One way to move towards understanding the most significant physical variables is for experienced researchers to identify those that are most plausibly linked to desired outcomes. This is the focus of Phase III of this research. The literature analysis provided input data for each of these phases. The following section describes the variables selected for inclusion in Phases II and III of this study.

Variables Selected for Use in Phases II and III

A subset of the studies described in the preceding section were used to seed the brainstorm lists for Phases II and III of this research. Once further research ceased to identify additional types of variables (e.g., lighting, school size, thermal conditions) that were studied with respect to educational outcomes, the active search for additional studies was halted. All of the studies that had been acquired prior to the development of the seeded brainstorm list for Phase II (January, 2003) were used in the following two research phases and are listed in Appendix A. Additional studies acquired after January, 2003 were included in the literature review above, but were not utilized in Phases II and III. For each study listed in Appendix A, the following items are described: the source; the subjects studied; independent (including controls) and dependent variables; how each variable was measured; and the relationships identified among the variables.

The specific variables utilized in Phases II and III are listed in the following two sections. Each variable identified as a dependent variable in Appendix A was used in Phase II, and each variable identified as an independent variable was used in Phase III, with exceptions (described below).

Variables for Phase II – Concept Mapping Exercise

The first activity that participants in Phase II were asked to complete required them to brainstorm a list of measures of student, school, or school district success. They were given a list of items (dependent variables derived from the literature), shown in Table 3.1, to stimulate their thinking. The original intent was to focus specifically on *student* outcomes, so only those dependent measures involving students were included in the seeded brainstorm list (although educators added teacher-related outcomes during the brainstorming exercise). However, teachers added teacher-related outcomes when they were asked to brainstorm a list of measures of student, school, or school district success during Phase II. All student-related dependent variables identified in Appendix A were included, with two exceptions (enduring effects such as participation in college extracurricular activities, and perceived privacy). These two items were not intentionally omitted, but this error was discovered after the brainstorming activity had gone out. In table 3.1, the source is listed in the right-hand column if the study specifically evaluated the outcome variable, or if the outcome variable was part of the measurement for a broader outcome variable.

Table 3.1. Student Outcome Variables Derived from the Literature

Student Outcome Variables	Source
Attendance	Bowers and Burkett (1987); Lewis (2000); O'Neil and Oates (2000); Cotton (1996); Fowler (1995)
Attitude/Student attitudes toward their school	Chan (1982); Cheng (1994); Lackney (1996); Cotton (1996); Weinstein (1979); McGuffey (1982); Fowler (1995)
Blood pressure	Grangaard (1995)
College related variables (such as admission to college)	Cotton (1996); Fowler and Walberg (1991); Fowler (1995)
Distraction	Ahrentzen, S. and G. W. Evans (1984); Lackney (1996)
Dropout rate	Cotton (1996); Fowler (1995)
Graduates constructively employed	Fowler and Walberg (1991)
Health	Bowers and Burkett (1987); Lackney (1996)
Individual student affective performance	Cheng (1994)
Intellectual performance	Christie and Glickman (1980)
Interpersonal relations with other students and school staff	Cotton (1996)
Language acquisition	Evans and Maxwell (1997)
Level of extracurricular participation	Cotton (1996); McNeely et al. (2002); Fowler (1995)
Mathematics achievement	Wenglinsky (1997); Maxwell (1999); Fowler and Walberg (1991); Bowers and Burkett (1987); Cash (1993); Chan (1980); Heschong et al. (2002); Tanner (2000); Lewis (2000); O'Neil and Oates (2000)
Occurrences of discipline	Fowler and Walberg (1991); Bowers and Burkett (1987); Cotton (1996)
Off-task behavior	Cotterell (1984); Grangaard (1995)
Phoneme comprehension	Evans and Maxwell (1997)
Reading skills	Evans and Maxwell (1997); Heschong et al. (2002); Tanner (2000); O'Neil and Oates (2000); Maxwell (1999); Fowler and Walberg (1991)
Retention (students who have not dropped out of school)	Fowler and Walberg (1991)
Satisfaction with the classroom environment	Fowler (1995); Ahrentzen and Evans (1984)
School connectedness (students feel cared for and fell like a part of the school)	McNeely et al. (2002)
School distract average SAT mathematics score	Fowler and Walberg (1991)
School distract average SAT verbal score	Fowler and Walberg (1991)
Social behavior problems	Cotton (1996)

Table 3.1. (cont'd)

Student Outcome Variables	Source
Student achievement/student performance	McGuffey (1982); Fowler (1995); Cash (1993); Chan (1980); Edwards (1991); Heschong et al. (2002); Lewis (2000); O'Neil and Oates (2000); Johnson et al. (2002); Earthman, Cash and Van Berkum (1995); McGuffey (1982)
Student anxiety	Cotterell (1984)
Student behavior	Ott (1976); O'Neil and Oates (1997); Earthman, Cash and Van Berkum (1995); Weinstein (1979); McGuffey (1982);
Student self-concept	Cheng (1994)
Student social development	Lackney (1996)
Students unsuspended from school	Fowler and Walberg (1991)
Test characteristics (high school proficiency test)	Fowler and Walberg (1991)
Well-being (includes health symptoms)	Righi et al. (2002)

Variables for Phase III – Delphi Study

From the literature reviewed, physical variables were identified to seed the brainstorming exercise in Questionnaire 1 of Phase III. Table 3.2 lists the school building physical variables that were included from the sources analyzed. It was assumed that the participants in Phase III were familiar with SFE literature, so the seeded brainstorm list generated from the literature review conducted in this study did not include every single physical variable identified. The purpose of seeding the brainstorm list was to stimulate the Delphi panel members to identify relevant physical variables, rather than to provide them with a comprehensive list from the literature. In hindsight, for the sake of consistency and to reduce bias, *all* of the physical variables identified in the literature should have been included in the brainstorm list. The non-physical independent variables identified in Appendix A, such as social climate in the classroom or class master's leader behavior, were also excluded from the brainstorm list. The final list of physical variables used in Phase III is included in table 3.2. The source is listed in the right-hand column if the study specifically evaluated the physical variable, or if the physical variable was part of the measurement for a broader variable (e.g., “acoustics” is one measure of “building condition” as measured by Cash 1993).

Table 3.2. Physical Variables Derived from the Literature

Physical Variables	Sources
Acoustics	Cash (1993); Lackney (1996)
Aesthetics and appearance	Lackney (1996)
Age of the school building	O'Neil and Oates (2000); Earthman, Cash and Van Berkum (1995); McGuffey (1982); Bowers and Burkett (1987)
Aircraft noise	Evans and Maxwell (1997)
Building maintenance	McGuffey (1982)
Building renovations	Maxwell (1997)
Class size	Weinstein (1979); McNeely et al. (2002)
Classroom adaptability	Lackney (1996)
Climate control	Cash (1993)
Daylighting	Heschong et al. (2002)
Full-spectrum lighting	Ott (1976); Grangaard (1995)
Indoor air quality	Righi (2002)
Living view	Tanner (2000)
Natural ventilation	Heschong et al. (2002)
Outdoor rooms or spaces	Tanner (2000)
Perceived quality of classroom's physical environment	Cheng (1994)
Presence of absence of fluorescent lighting	Chan (1980)
Presence or absence of air conditioning	Chan (1980); Cash (1993)
Presence or absence of carpet	Chan (1980)
School building condition	Cash (1993); Edwards (1991); Lewis (2000); Earthman, Cash and Van Berkum (1995)
School enrollment/size (not square footage)	Edwards (1991); Johnson et al. (2002); Fowler and Walberg (1991)
Sensory stimulation	Lackney (1996); Ahrentzen and Evans (1984)
Site size	Earthman, Cash and Van Berkum (1995)
Thermal factors	McGuffey (1982)
Type of air conditioning	Heschong et al. (2002)
Type of artificial lighting	Grangaard (1995)
Underground facilities	McGuffey (1982)
Visual factors/seeing factors (broader than just lighting conditions, such as contrast between print and paper)	McGuffey (1982)
Visual stimulation	Ahrentzen and Evans (1984)
Wall color	Cash (1993); Chan (1982)
Windows (presence or absence, type)	Heschong et al. (2002); McGuffey (1982)

The following chapters (Chapters 4 and 5) explain specifically how these variables were used to seed the brainstorm lists for the concept mapping exercise for educators and the Delphi process for experienced SFE researchers.

CHAPTER 4

PHASE II - MEASURES OF STUDENT, SCHOOL, OR SCHOOL DISTRICT SUCCESS: CONCEPT MAPPING BY EDUCATORS

Purpose

Researchers have made some progress in understanding if and how school facilities affect educational outcomes. But, are we evaluating school facility effects on the outcomes that matter most to educators? Lackney (1996, p. 25) suggests that environment-behavior research regarding school environments has not led to improvements in environmental quality because "it has not, in many cases, addressed problems, concerns, issues and questions of relevance to educational practitioners," due partly to the differences in interests and goals of researchers and practitioners. It is fitting that researchers continue to build on previous studies to ensure that a new and expanded understanding of how schools affect students and teachers is acquired. Although there have been studies in which educators were asked about what types of environmental conditions or design elements affect specific educational outcomes (Lackney, 1996; Heery International, 2000), there have been no studies in which educators have identified and rated measures of student, school, or school district success and SFE researchers identified the most plausible relationships between physical variables and those important outcomes.

It is important to ask educators who work in school systems what types of outcomes (e.g., achievement, behavior, and health) they believe reflect whether or not their students, schools, or school districts are succeeding because they are acutely aware of the types of outcome measures that are used to rate students and schools, and what important measures are not currently tracked. *The purpose of Phase II of this study is to identify educational outcomes (i.e., measures of student, school, and school district success) that educators believe are important to monitor or otherwise track*. The outcomes from Phase II of the research included:

- A list of measures of student, school, and school district success, as generated by educators;
- Clusters (or categories) containing these measures; and
- Average ratings for each measure of success and cluster to indicate how important educators feel it is to monitor or otherwise track those measures.

The data acquired in this phase, specifically the rated measures of student, school, or school district success, were used in Phase III (Chapter 5) in which researchers were asked to identify physical variables and develop hypotheses linking them with measures of success identified in Phase II.

The following section describes, in detail, the methodology used in Phase II, as well as the specific findings from each step in the process. A discussion of those findings follows.

Specific Methodology and Findings

An overview of the concept mapping methodology has been provided in Chapter 2. The concept mapping methodology developed by Trochim (1989) was adapted to serve the purpose of this particular study. Whereas concept mapping is often used for planning or evaluation purposes, this study utilizes it to solicit measures of student, school, or school district success from educators, to categorize these concepts, and rate their importance. The following sections describe each of the six steps in the concept mapping process: prepare the project; generate ideas; structure ideas; interpret maps; and utilize maps.

Step 1: Prepare the Project

The first phase in concept mapping is to prepare the project. As with any project, planning is crucial to ensure that goals are achieved. During this step, participants are identified, the focus and rating statements are finalized, and a schedule is developed. The specific desired outcomes of this step include developing: 1) a diverse and representative group of educators with experience in education in K-12 schools to participate in the study; 2) a defined list of demographic information to obtain from educators (for the purpose of determining representativeness and comparing subgroups, if applicable); 3) a finalized focus statement to help educators identify educational outcomes; 4) a finalized rating focus statement to solicit educators' opinions regarding which educational outcomes are important to track; 5) a ready-to –use software prepared so that all of the educators can participate in the sorting and rating exercise; and 6) a schedule for completion of the study to ensure that data are collected in a timely manner. A detailed description of how these outcomes were achieved follows, beginning with the selection of participants.

Select participants

The first step in preparing the project is the selection of participants. This step must be carefully taken to ensure that the participants represent, to some degree, the population of interest. Although concept mapping may be done with fewer than ten participants to more than seventy-five, groups of ten to twenty are reasonable for ensuring that the group is not too large for meaningful discussion yet large enough so that a variety of opinions are captured (Trochim, 1989). For this study, a convenient, yet purposive sampling strategy was used to select participants. Anticipating the difficulties associated with gathering busy educators from a variety of schools and districts into one place for this study, a group of educators seeking advanced degrees at a single institution were invited to participate. A cohort of eighteen doctoral students pursuing their Doctorate in Education in School Improvement at the State University of West Georgia[1] was identified and agreed to be involved with this study. This group was selected because it included educators in various positions from several counties in Georgia. The instructor was willing to assist with this project and invite her students to participate, since they would soon be conducting dissertation research of their own.

Define participant demographics

For the purpose of examining subgroups later and to establish generalizability or representativeness, demographic information about the participants was collected. For this study, the demographic variables in Table 4.1 were included.

[1] The purpose of this unique program is to "develop change agents and transformational leaders who can collaboratively plan and initiate change in the schools they serve." The title of the course into which this project was incorporated is "Developing Innovative Teaching and Learning Environments to Facilitate School Improvement." The course is designed so that "students will analyze an existing school environment, propose strategies for improving measures of school quality, and develop an action plan for implementation" (www.westga.edu/edd/mission.html).

Table 4.1. Participant Demographics

Participant Demographics Information Acquired	Comment	Summary Data
Job Position	Represent those of participants; Not enough members of each subgroup to yield meaningful comparisons	Principals and assistant principals = 8 Counselors = 4 Teachers = 3 Administrative assistant whose role is similar to an assistant principal = 1 Associate school superintendent = 1
Grade Level Served	All K-12 grade levels included	Primary (K-2) = 2 Intermediate (3-5) = 1 Elementary (K-5) = 5 Middle (6-8) = 2 High (9-12) = 6 Other = 1 (board of education)
Number Years Working in K-12 Education (1-60)	Broad enough to allow anyone to select the appropriate number	Average = 16 years (no one served less than 7 years) Total = 278 years
School Type	Intended to include all types of schools	Suburban schools = 12 Urban = 2 Rural = 2 Multiple schools = 1
Age	Begins with a common age, 22, when students complete a bachelor's degree	22-30 = 1 31-40 = 7 41-50 = 6 51-60 = 3
Gender		Male = 5 Female = 12
School size/enrollment	Selected to provide enough discrete categories so the comparisons of "small" versus "large" schools could be made	< 300 = 0 300-400 = 1 400-500 = 1 500-600 = 3 600-900 = 1 900-1200 = 6 1200-1500 = 2 1500-2000 = 2 2000-2500 = 1

When comparing the percentages of schools at each grade level represented by participants in this study to those in the state of Georgia, the following data emerged:

	Respondents	**State of Georgia**
Elementary	50%	61%
Middle	13%	20%
High	38%	18%

This indicates that the study population may be more inclined to consider measures of success that are of greater importance at the high school level. The respondents represented eleven different school districts, quite a variety for just seventeen respondents, accounting for approximately six percent of the 180 school districts in the state of Georgia.

Develop brainstorming focus and rating focus

Once the facilitator has determined what types of participant demographics information will be required, the next step in the planning process is to develop the brainstorming focus and rating focus statements. The focus statement must be carefully determined. For this research, the goal was to identify educational outcomes that are important to educators to monitor or otherwise track. The literature regarding SFE includes variables at the individual, school, and school district levels. (e.g., individual student behavior, school dropout rate, district average SAT scores). The terms “educational outcomes” and “student outcomes” occur in the literature, but the course

Focus Statement

One measure of student, school, or school district success (or lack of success) is:

instructor suggested that these terms would not have much meaning to the participants. The final focus statement was written so that participants were asked to complete the statement with words or short phrases (no limit on the number).

Once the educators identified measures of student, school, or school district success, they rated how important it is to monitor or otherwise track each of those measures. For each statement generated in the brainstorming session, the participants were asked to respond to the following rating focus statement developed during this step of the process.

Rating Focus

How important do you believe it is to monitor (or otherwise track) this measure of student, school, or school district success?

1	2	3	4
Unimportant			Important

Assign sorts and rating

The purpose of this step is simply to decide who, among the group of participants, will be selected to sort and rate the measures of success identified during the brainstorming session. It is not imperative, using a concept mapping approach, for all participants to engage in every step of the process. For this study, all participants were selected to sort and rate the measures of success. Using software[2], each user was set up to complete the sorting and rating exercises prior to meeting together.

[2] The Concept System software purchased from Concept Systems, Inc. (www.conceptsystems.com) was used in this study.

Develop schedule

Every step in the concept mapping process may be carried out either in-person, where all participants gather in one place, or remotely, where participants engage via e-mail. The schedule for this project was based on conducting the brainstorming exercise via e-mail, and completing the sorting and rating exercise and map interpretation in person. The entire concept mapping process was scheduled to occur during the month of February, 2003. Once the entire project was prepared in step 1, it was time to begin gathering data in step 2.

Step 2: Generate Ideas (Brainstorming)

Once the focus and rating statements were developed during the planning step, the participants were brought together to actually complete those tasks. In order to minimize the in-person time required by participants, the brainstorming exercise was conducted via e-mail. The brainstorm exercise was seeded with educational outcomes identified in the SFE literature. Table 4.2 lists the twenty-seven sources from which outcome measures were obtained. An explanation of how the variables identified from these sources were selected for inclusion on the brainstorming list was provided in Chapter 3. The list includes seminal SFE studies and is comprised of literature that evaluates the links between educational outcomes and physical conditions, school size, class size, and other types of independent variables.

Table 4.2. Sources of Seeded Brainstorm Concepts

Sources of Student Outcomes	
Ahrentzen & Evans, G. W. (1984). Distraction, privacy, and classroom design. *Environment and Behavior, 16*(4), 437-454.	Heschong et al. (2002). Daylighting impacts on human performance in school. *Journal of the Illuminating Engineering Society, 31*(2), 101-111.
Bowers and Burkett (1987). *Relationship of Student Achievement and Characteristics in Two Selected School Facility Environmental Settings*. Paper presented at the 64th Council of Educational Facility Planners, International Conference, Alberta, Canada.	Johnson, Howley, & Howley, A. A. (2002). *Size, Excellence, and Equity: A Report on Arkansas Schools and Districts*. Athens, OH: Ohio University.
Cash (1993). *Building Condition and Student Achievement and Behavior.* Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Blacksburg, VA.	Lackney (1996). *Quality in school environments: A multiple case study of the diagnosis, design and management of environmental quality in five elementary schools in the Baltimore city public schools from an action research perspective*. Doctoral Dissertation, College of Architecture, University of Wisconsin, Milwaukee, WI.
Chan (1980). *Physical Environment and Middle Grade Achievement* (EA 015 130). Greenville, SC: South Carolina School District of Greenville County.	Lewis (2001). Where Children Learn: Facilities Conditions and Student Test Performance. *CEFPI Issue Track* (December 2000), 4.
Chan (1982). *A Comparative Study of Pupil Attitudes Toward New and Old School Buildings* (EA 015 130). Greenville, SC: School District of Greenville County.	Maxwell (1999). *School building renovation and student performance: One district's experience*. Council of Educational Facility Planers International.
Cheng (1994). Classroom environment and student affective performance: An effective profile. *Journal of Experimental Education, 62*(3), 221-239.	McGuffey, C. W. (1982). Facilities. In H. J. Walberg (Ed.), *Improving Educational Standards and Productivity* (pp. 237-281). Berkeley, CA: McCutchan Publishing Corporation.
Christie and Glickman (1980). The effects of classroom noise on children: Evidence for sex differences. *Psychology in the Schools, 17*(3), 405-408.	McNeeley et al. (2002). Promoting school connectedness: Evidence from the national longitudinal study of adolescent health. *Journal of School Health, 72*(4), 138-146.
Cotterell (1984). Effects of school architectural design on student and teacher anxiety. *Environment and Behavior, 16*(4), 455-479.	O'Neil and Oates (2000). The impact of school facilities on student achievement, behavior, attendance, and teacher turnover rate in central Texas middle schools.
Cotton (1996). *School size, school climate, and student performance*. The Northwest Regional Educational Laboratory. Available: http://www.nwrel.org/scpd/sirs/10/c020.html [2002, December 16].	Ott (1976). Influence of fluorescent lights on hyperactivity and learning disabilities. *Journal of Learning Disabilities, 9*(7), 22-27.

Table 4.2. (cont'd).

Sources of Student Outcomes	
Earthman, Cash and Van Berkum (1995). *A statewide study of student achievement and behavior and school building condition*. Paper presented at the Annual Meeting of the Council of Educational Facility Planners, International, Dallas, TX.	Righi et al. (2002). Air quality and well-being perception in subjects attending university libraries in Modena (Italy). *The Science of the Total Environment, 286*, 41-50.
Edwards (1991). *Building Conditions, Parental Involvement and Student Achievement in the D.C. Public School System*. Unpublished Master's thesis, Georgetown University, Washington, D.C.	Tanner (2000). The influence of school architecture on academic achievement. *Journal of Educational Administration, 38*(4), 309-330.
Evans and Maxwell (1997). Chronic noise exposure and reading deficits: The mediating effects of language acquisition. *Environment and Behavior, 29*(5), 638-657.	Weinstein (1979). The physical environment of the school: A review of the research. *Review of Educational Research, 49*(4), 577-610.
Fowler (1995). School size and student outcomes. In B. Levin & H. J. Walberg & W. J. Fowler (Eds.), *Organizational Influences on Educational Productivity* (Vol. 5). Greenwich, CT: JAI Press, Inc.	Wenglinksky (1997). *When Money Matters*. Princeton, NJ: Policy Information Center.
Grangaard (1995). *Color and Light Effects on Learning*. Paper presented at the Association for Childhood Education International Study Conference and Exhibition, Washington, DC.	

The table presented in Appendix A was utilized to identify the variables studied in the SFE literature. Using this matrix, dependent variables that related to student outcomes were selected to comprise the list that seeded the brainstorming exercise. The language of the original sources was preserved to avoid incorporating researcher bias or interpretation. The original list of concepts based on the literature is included in Table 4.3.

Table 4.3. Original Brainstorming Concept List Based on the Literature Review

Brainstorming Concept List (In Alphabetical Order)		
Attendance	Level of extracurricular participation	Student achievement
Attitude	Mathematics achievement	Student anxiety
Blood pressure	Occurrences of discipline	Student attitudes toward their school
College related variables (such as admission to college)	Off-task behavior	Student behavior
Distraction	Phoneme comprehension	Student performance
Dropout rate	Reading skills	Student self-concept
Graduates constructively employed	Retention (students who have not dropped out of school)	Student social development
Health	Satisfaction with the classroom environment	Students unsuspended from school
Individual student affective performance	School connectedness (students feel cared for and fell like a part of the school)	Test characteristics (high school proficiency test)
Intellectual performance	School distract average SAT mathematics score	Well-being (includes health symptoms)
Interpersonal relations with other students and school staff	School distract average SAT verbal score	
Language acquisition	Social behavior problems	

Participants were given the list in Table 4.4, via e-mail, and asked to add to, re-word, or delete measures from the list. A total of ten participants responded to the brainstorming exercise on time. The concept mapping methodology allows a sub-group of participants to generate the concepts, so this was not problematic. Although a brainstorming exercise, participants were allowed to delete items for two reasons: first, to reduce the likelihood that the list would become too long to handle in the sorting and rating exercise; and secondly to minimize frustration that might be caused by sorting and rating concepts that the educators really did not consider to be measures of success. If one participant suggested that an item be deleted, it was, unless another participant suggested that it be included, in which case it was kept on the list. The participants were not required to provide a rationale for suggesting that items be deleted. Consistency was maintained in the deletion of items. Consequently, the following measures of success were deleted or reworded, based on participant feedback (Table 4.4).

Table 4.4. Deleted or Reworded Concepts

Blood pressure - deleted	School district average SAT verbal scores - deleted
Dropout rate - deleted	Social behavior problems - deleted
Distraction - deleted	Student anxiety - deleted
Graduates constructively employed - deleted	Test characteristics - deleted
Health - deleted	Well-being - deleted
Intellectual performance - deleted	Occurrences of discipline: one recommended that this be changed to "occurrences of discipline consequences" and another recommended keeping it on the list – kept on the list with recommended rewording
Satisfaction with the classroom environment - deleted	Phoneme comprehension reworded to "phonemic awareness through primary
School district average SAT math scores -- deleted	Students unsuspended from school reworded to become two statements: in-school suspensions and out-of-school suspensions

Step 3: Structure ideas (sorting and rating)

Once the final list of concepts was generated during the brainstorming exercise, the participants met during a regularly scheduled class session to complete the third step. The outcome from this step was a set of individually sorted and rated measures of success that were combined to create the point maps, cluster maps, and rating maps previously described. The session began with an introduction by the facilitator (i.e., the researcher conducting this dissertation study), her motivation for conducting this study, and an overview of the concept mapping process. The participants were provided with a handout of the final list of measures of success generated during brainstorming, as well as instructions for sorting and rating them. A copy of the handout is included in Appendix B. There was some discussion to clarify the meaning of some of the measures. Table 4.5 includes the final measures of success used in the sorting and rating exercise.

Table 4.5. Final Statements for Sorting and Rating

Final Statements for Sorting and Rating (In No Particular Order)			
Attendance	Attitudes	College-related variables (such as admission to college)	Individual student affective performance
Interpersonal relations with other students and school staff	Language acquisition	Level of extracurricular participation	Mathematics achievement
Off-task behavior	Phonemic awareness through primary grades	Reading skills	Retention (students who have not dropped out of school)
School connectedness (students feel cared for and feel like a part of the school)	Student achievement	Student attitudes toward their school	Acceptable student behavior
Student performance	Student self-concept	Student social development	Asthma
Arthritis	Fibromyalgia	Back pain	Tutoring
After and before school programs	Parent resource centers	Parenting workshops	Extracurricular enrichment activities
Buildings and grounds clean and well maintained	Resources are well maintained and up to date	Teacher/administrator retention	Teacher/administrator absentee rates
Teacher/administrator graduate degrees	Teacher/administrator feelings of efficacy	Teacher/administrator years of experience	Teacher/administrator participation in professional development
Teacher/administrator levels of collaboration	Teacher/administrator general levels of satisfaction	Teacher/administrator special awards, honors, or accomplishments	Teacher/administrator participation in professional organizations
Teacher/administrator complaint hearings	Teacher/administrator disputes	Teacher/administrator lawsuits	Teacher/administrator disciplinary actions
Teacher/administrator referrals for counseling	Teacher/administrator levels of evaluation	Teacher/administrator mental health concerns	Incidences of workmen's compensation
Incidences of use of counseling services by teachers/administrators	Estimated amount of money teachers spend out-of-pocket on school expenses	Support services provided (paraprofessionals, secretarial, etc)	Parental Involvement
Parental Satisfaction	Involvement in Community Service Projects	Public Relations	Students who are "team players"
General and Special Education Cohesiveness	Student attitude toward physical activity and lifelong fitness	Student short-term Post Secondary Goals attained	Student satisfaction with post secondary preparation
Community Business satisfaction with student employees and graduate employees	Community involvement	Socio-economic status	Movement to different schools during school career
School size	Average class size (not teacher:student ratio)	Length of time 'in-country' for immigrant students	Multiple retentions

Table 4.5. (cont'd).

Final Statements for Sorting and Rating (In No Particular Order)			
Graduation Test score performance	SAT scores - school	SAT scores - student	ACT scores - school
ACT scores - student	Graduates enrolled in college (Admission does not necessarily mean enrollment....)	Joint enrollment participation levels	Experience/educational level of teaching staff
Alternative school placement	Advanced Placement offerings	Advanced Placement enrollment	Advanced Placement test scores
National Merit Scholar program results	Governor's Honors participation	In-School discipline suspensions	Out-of-School discipline suspensions
Community involvement	Creativity	Academic growth	Special talents
Post-graduate study and success	Feedback from the community and alumnae	Interest in continuing education	Student perceptions
Sense of community	Student/teacher interaction in the learning environment	Student friendly environment	Staff development
Teacher mentoring	Staff level of academic achievement	Availability of materials and other resources	Teach/Assess/Re-teach cycle
Teacher verbal ability	Teacher support (i.e., induction program, availability of instructional leadership like an ILT, etc.)	Participation in PHS courses	
Vertical teaming within the school and with feeder schools, as well as schools that students feed into	Standardized test scores (appropriately used)	Student transience rate	

The facilitator demonstrated how to use the Concept System software. Participants were then asked to enter their user information (name, phone number, etc.) and the requested demographic information. Next, they rated each measure of student, school, or school district success as to how important (on a four-point scale) they believe it is to monitor or otherwise track it. Unfortunately, although eighteen computers were set up for the exercise, one failed and therefore one participant (one of two latecomers) had to sit out of the exercise.

After completing these steps, the participants sorted the measures into categories that made sense to them. There are a few simple rules to follow when sorting statements (Table 4.6).

Table 4.6. Rules for Sorting Statements in Concept Mapping

Statement Sorting Rules
Group the statements for how similar in meaning they are to one another. You will be creating a main topic name for each pile you create. Do not group the statements according to how important they are, how high a priority they have, etc. Another part of the process will ask you how important you believe each idea is. 1. There is no right or wrong way to group the statement. You will probably find that you could group the statements in several sensible ways. Pick the arrangement that feels best to you. 2. You cannot put one statement into two piles at the same time. Each statement must be put into only one pile. 3. People differ on how many piles they wind up with. In most cases, anywhere from 10 to 20 piles usually works out well. 4. A statement may be put alone as its own pile if you think it is unrelated to the other statements or it stands alone as a unique idea, but you cannot have one pile for each statement. 5. Make sure that EVERY statement is put somewhere. Do not leave any statements out. Do NOT create any piles that are “miscellaneous” or “junk” piles. If you have statements left over that you cannot place, put each statement in its own pile.

The participants who finished first completed the entire exercise in approximately twenty minutes. Those who took the longest to complete it took approximately forty minutes. Sorting and rating data developed by each individual obtained in this step were combined and used to compute the maps, as described in the next section.

Following the sorting and rating exercises, the participants were asked to describe their thought processes on how they clustered the statements. Some stated that several statements were grouped on the original list, like medical issues or test scores, which lent themselves to clusters. Also, some broad categories are commonly referred to among educators such as the affective domain, community, test scores, achievement, parents, professional development, discipline, illness, etc. They started with these and then filled in others as necessary to have categories for all items. One person grouped the statements according to who was affected by each item (e.g., parents, students, etc.).

The educators rated the following measures of success as important (average rating of 3.2 or higher) to monitor or otherwise track (Table 4.7) based on a four-point Likert-type scale (1 = unimportant, 4 = important). The cut-off value of 3.2, although somewhat arbitrary, has been used consistently throughout the study to represent important items. This cut-off value includes approximately one third of the entire list of measures of student, school, or school district success. Table 2.7 also shows which measures of success would have been omitted had a higher cut-off value been chosen. A cut-off of 3.5 would have included only the top twelve percent of all measures of success.

Table 4.7. Top Rated Measures of Success

Measure of Student, School, or School District Success	Avg Rating
Reading skills	3.82
Attendance	3.75
Staff development	3.71
Mathematics achievement	3.65
Parental involvement	3.65
Academic growth	3.59
Student performance	3.59
Student achievement	3.59
Language acquisition	3.59
Teacher/administrator retention	3.59
Teacher/administrator participation in professional development	3.53
Teacher mentoring	3.53
Student friendly environment	3.53
Average class size (not teacher: student ratio)	3.47
Community business satisfaction with student employees and graduates	3.47
Teacher/administrator general levels of satisfaction	3.47
Phonemic awareness through primary grades	3.41
Student transience rate	3.41
General and Special Education Cohesiveness	3.41
Teacher/administrator levels of collaboration	3.41
School size/enrollment	3.35
Student satisfaction with post secondary preparation	3.35
School connectedness (students feel cared for and feel like a part of the school)	3.35
Individual student affective performance (includes self-concept, attitudes toward peers/school/teachers, self-efficacy of learning, etc.)	3.35
Graduation Test score performance	3.29
Teacher/administrator absentee rates	3.29
Teacher support (i.e., induction program, availability of instructional leadership training, etc.)	3.29
Student attitudes toward their school	3.29
Support services are provided (paraprofessionals, secretarial, etc)	3.29
Parental Satisfaction	3.24
Length of time 'in-country' for immigrant students	3.24
Attitudes	3.24
Multiple retentions	3.24
Acceptable student behavior	3.24
Community involvement	3.2

The selection of a lower cut-off value, such as 3.0, for example, would have included more than fifty percent of the measures of success. Table 4.8 lists additional measures of success that would have been included in the top-rated list, had this cut-off been selected.

Table 4.8. Measures of Success Rated Between 3.0 and 3.2

Measure of Student, School, or School District Success	Avg Rating
Student/teacher interaction in the learning environment	3.18
Student short-term post secondary goals attained	3.18
Resources are well-maintained and up to date	3.18
Feedback from the community and alumnae	3.18
Availability of materials and other resources	3.18
Teacher/administrator feelings of efficacy	3.12
Teacher verbal ability	3.12
Standardized test scores (appropriately used)	3.12
Sense of community	3.12
College-related variables (such as admission to college)	3.12
Teach/assess/re-teach cycle	3.06
SAT scores – student	3.06
Public relations	3.06
Interpersonal relations with other students and school staff	3.06
Experienced/educational level of teaching staff	3.06
Buildings and grounds clean and well-maintained	3.06
ACT scores – student	3.06
Teacher/administrator graduate degrees	3.00
Student social development	3.00
Retention (students who have not dropped out of school)	3.00
Occurrences of discipline consequences	3.00

Although Delphi panel members were asked to focus on the measures of student, school, or school district success rated as important by the educators, it is unlikely that the selection of a higher or lower cut-off value would have had much of an effect on the final research priorities they selected since they were given the entire list of measures of success to choose from when developing their research hypotheses.

Step 4: Compute Maps

In step 4, the acquired data are transformed into point, cluster, and rating maps - visual pictures that represent the group's thinking. At the completion of this process, the entire set of measures of success has been grouped into categories and rated according to relative importance, using group averages. The facilitator examined the clusters, beginning with the highest number of clusters, and continuing downwards until the number of clusters is as small as possible, while providing as much distinction as possible between clusters. The software allowed the user to look at any number of clusters and examine the statements included in each one. Based on the educator data in this study, fifteen clusters were selected because there were meaningful distinctions among the clusters that were not present when only fourteen clusters were used. There was no obvious meaning in the distinction among the clusters when sixteen clusters were selected. Table 4.9 shows how a group of statements are clustered when fourteen, fifteen, and sixteen clusters were selected. All other clusters except those shown in this table were the same regardless of whether fourteen, fifteen, or sixteen clusters were selected.

Table 4.9. Variations Based on Selection of 14, 15 or 16 Clusters

Statement	Cluster Name (into which the statement was assigned)		
	14 Clusters	**15 Clusters**	**16 Clusters**
Teacher/administrator feelings of efficacy	Teacher Evaluation	Teacher Evaluation	Teacher Evaluation
Teacher/administrator general levels of satisfaction	Teacher Evaluation	Teacher Evaluation	Teacher Evaluation
Teacher/administrator complaint hearings	Teacher Evaluation	Teacher Evaluation	Teacher Evaluation
Teacher/administrator disputes	Teacher Evaluation	Teacher Evaluation	Teacher Evaluation
Teacher/administrator lawsuits	Teacher Evaluation	Teacher Evaluation	Teacher Evaluation
Teacher/administrator levels of evaluation	Teacher Evaluation	Teacher Evaluation	Teacher Evaluation
Teacher/administrator disciplinary actions	Teacher Evaluation	Teacher Evaluation	Third Cluster (unlabeled)
Teacher/administrator referrals for counseling	Teacher Evaluation	Teacher Evaluation	Third Cluster (unlabeled)
Incidences of use of counseling services by teachers/administrators	Teacher Evaluation	Teacher Evaluation	Third Cluster (unlabeled)
Teach/assess/re-teach cycles	Teacher Evaluation	Teacher Evaluation	Third Cluster (unlabeled)
General and special education cohesiveness	Teacher Evaluation	Collaboration	Collaboration
Vertical teaming within the school and with feeder schools (as well as schools that students feed into)	Teacher Evaluation	Collaboration	Collaboration

The difference between fourteen and fifteen clusters is meaningful. The two statements that were differentiated into a separate cluster are both related to collaboration, and as such are distinct from other statements in the larger cluster, Teacher Evaluation. However, the difference between fifteen and sixteen clusters does not appear to be meaningful. The four statements that are differentiated into a third cluster do not appear to have any particular link to one another that would separate them from the other statements in the Teacher Evaluation cluster. Since there is no obvious meaningful difference between these groups of statements, fifteen clusters were selected.

The cluster rating map also indicates the relative importance of the clusters. By examining the data behind the map, the average importance ratings of each cluster emerge. These are listed in Table 4.10.

Table 4.10. Average Cluster Ratings

Cluster Name	**Avg. Importance Rating (1-4 scale)**
Achievement data	3.25
Parental involvement	3.13
School factors (e.g., attendance, school size, after & before school programs)	3.12
Facilities	3.12
Community (e.g., community involvement, public relations)	3.12
Collaboration	3.09
Staff training, experience & expertise	3.08
Post-secondary concerns (e.g., student satisfaction with post-secondary preparation, college-related variables)	3.06
School climate (e.g., student friendly environment, student self-concept)	3.01
Student behavior	2.91
Student attitude	2.81
Academics/placement (e.g., retentions, advanced placement enrollment)	2.77
Teacher attitude and behavior	2.66
Support services (e.g., availability of materials and other resources, teacher/administrator mental health concerns)	2.63
Health	1.49

Step 5: Interpret Maps

One week after the sorting and rating exercise, participants were shown the point map, cluster rating map, and other pertinent information resulting from their work (See Appendix C for the Powerpoint presentation). A handout showing the clusters, their statements, and average ratings was provided. The participants were allowed to move a statement from one cluster to another, although the software does not allow an entire cluster to be deleted. The researcher then went systematically down the list to gain consensus from the group regarding cluster labels and statement moves. After a discussion, there was general consensus within one hour. The final cluster rating map is shown in Figure 4.1.

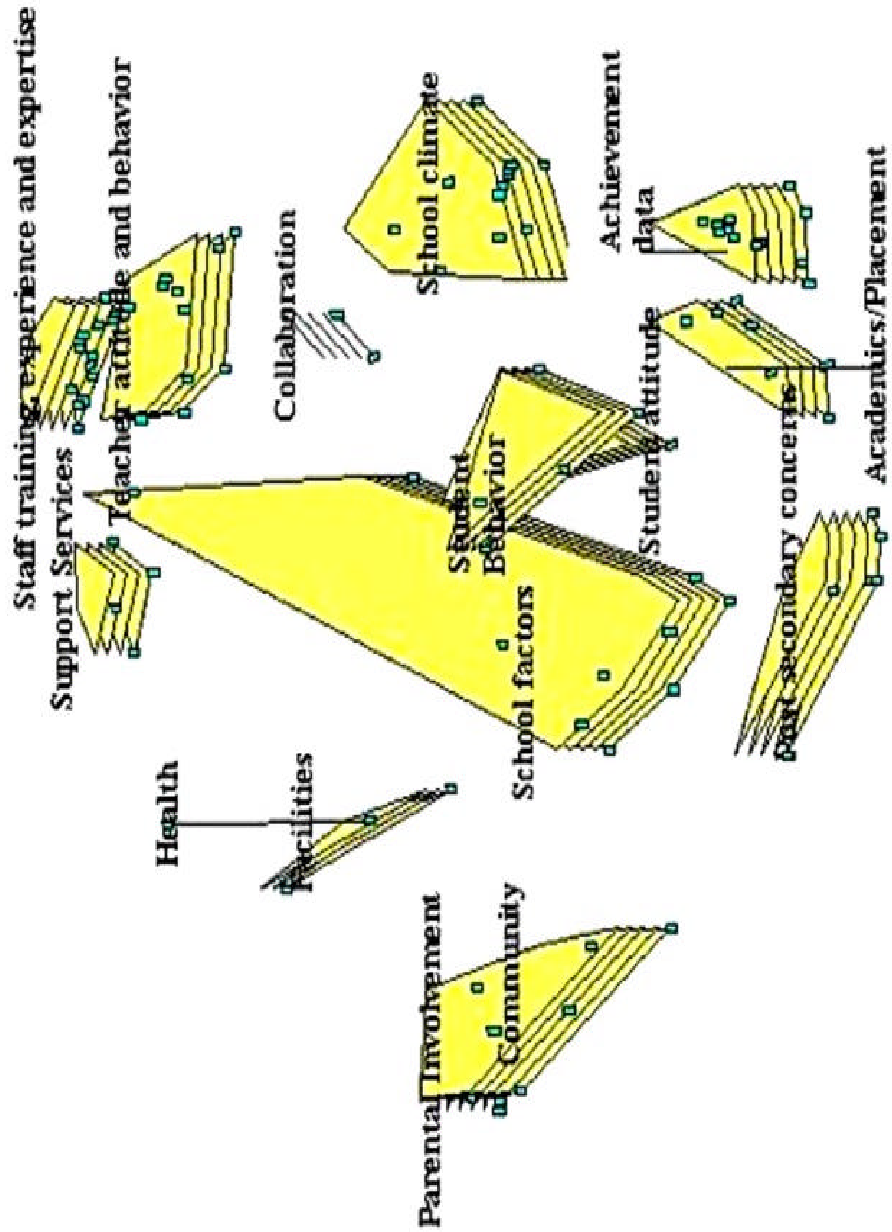


Figure 4.1. Final Cluster Rating Map

Step 6: Utilize Maps

The final step in the concept mapping process is map utilization. Typically, according to the concept mapping method, the participants are asked to determine how the maps will be used to enhance their planning or evaluation effort (Trochim, 1982). Trochim suggests, for example, that a group might choose to assign people into task forces to address planning issues related to each cluster. Or, the clusters may be used to develop an outline of a planning report, to develop training modules regarding a new program, or to develop a questionnaire. In the case of this dissertation, data from the cluster rating map were used to develop Questionnaire 3 during Phase III of the Delphi study (Chapter 5). The maps and reports generated from the data in Phase II were also used to identify several measures of success that have not yet been studied with respect to the physical environment (further discussed in Chapter 6), indicating that there may be important gaps in our understanding of how school facilities affect those under-evaluated measures of student, school, or school district success.

Discussion

The concept mapping method was appropriate for accomplishing the goals of Phase II. Some lessons learned from applying this method have been provided in Appendix D. Concept mapping provided an effective means for asking educators to identify, rate, and cluster measures of student, school, or school district success in a timely manner. The data were readily used in Phase III of this study. However, the final concept map itself proved to be less useful than the data it contained. Although the cluster rating map identified fifteen groupings of measures of student, school, or school district success and their relative importance, it was the statements contained within these clusters that proved to be most useful in this study. What is evident from the cluster ratings (Table 4.10), however, is that although educators do believe that academic achievement (rating = 3.25) is the most important type variable to track, other types of variables, such as parental and community involvement, school factors (e.g., attendance, average class size, and student transience), and facility resources are nearly just as important. During discussions, educators expressed dissatisfaction with the way academic achievement is currently measured using only standardized tests.

Regarding facilities, it is important to note that the educators added two facility-related variables (without any prompting) to the brainstorm list (including, resources are well-maintained and up-to-date; building and grounds clean and well-maintained) and rated both of them above 3.0. More than one educator commented that information about school facilities is entirely absent from most teacher and administrator preparation courses, although it is needed.

An unexpected result in Phase II was the identification of measures of student, school, or school district success that seemed to be independent variables rather than outcome variables (e.g., average class size, school size/enrollment, socioeconomic factors). Although one might consider socioeconomic status to be a measure of success, it is not going to be affected by anything the school can provide. Some identified measures of success could either be independent or dependent variables, depending on the hypothesis that might be tested. For example, teacher/administrator levels of collaboration might be an independent variable that affects student academic achievement, or it could be a dependent variable affected by whether or not the school provides quality faculty collaborative spaces. This was not problematic for this study, however, since the Delphi panel members in Phase III could choose any of the measures of success as dependent variables when suggesting priority hypotheses for future research.

The sample of educators chosen to participate in Phase II was selected purposively to represent a “typical” case. Among the seventeen participants, there were only three who are currently teachers. Although nearly half of the participants were principals and assistant principals, these educators were most likely teachers prior to assuming their current job positions. Although an attempt was made to explain variability among educator responses to the sorting and rating exercise, there were no clear patterns that emerged. Although it is not anticipated that a replication of this study with a larger or different population of educators would yield the same exact set of educational measures or the same quantitative importance ratings, it is likely that the broader categories (i.e., clusters) that they identified as important would generalize to a broader population of educators. It would strengthen the confidence of the findings if there were educational policy or guidance recommending that school systems track the types of educational outcomes that educators perceive as important. However, the focus of student and school evaluation, including for the *No Child Left Behind Act*, continues to be on academic achievement as measured by standardized tests. There is a need to replicate Phase II with other groups of educators or to follow it up with a large-scale survey to determine if the outcome measures rated as important to educators in this study are also important to a larger sample.

CHAPTER 5

PHASE III - IDENTIFYING PLAUSIBLE RELATIONSHIPS BETWEEN PHYSICAL FACTORS AND MEASURES OF STUDENT, SCHOOL, OR SCHOOL DISTRICT SUCCESS

Purpose

Is there sufficient evidence from the SFE field to help school designers and other decision-makers create and maintain schools that best support teaching and learning? Phase II has shown that there are outcome variables, such as staff development, teacher/administrator levels of collaboration, and student transience rates that have not been evaluated with respect to physical facilities. While progress has clearly been made in this field, a formally stated set of research priorities to guide future research does not exist. Currently, researchers in a wide variety of disciplines and sub-specialty areas continue to build on past research, but without any particular future direction to help them focus on the most plausible links between the physical environment and educational outcomes that are important to educators. *The purpose of Phase III is to identify the most plausible relationships between a set of high priority physical factors and measures of success rated as important by educators for the purpose of identifying research priorities for the SFE field.*

The following sections of this chapter describe the specific methodology used to accomplish the goals of Phase III, and describe the specific findings from this study.

Methodology and Findings

The Delphi method (Delbecq et al., 1975) was chosen for data collection and analysis in Phase III (described more generally in Chapter 2) to identify plausible relationships and to develop research priorities. This method is useful for soliciting knowledge and information from experts to arrive at some level of consensus about how to address a complex problem. The study involved a series of four questionnaires given to a group of experienced researchers – panel members who are very familiar with SFE research. The specific methodology used in this research is further described in the following sections: Delphi panel member selection; Questionnaire 1; Questionnaire 2; Questionnaire 3; and Questionnaire 4. Each Questionnaire section includes a description of both how the questionnaire was developed, as well as the results. The overall approach to this study using the Delphi method is described in Figure 5.1.

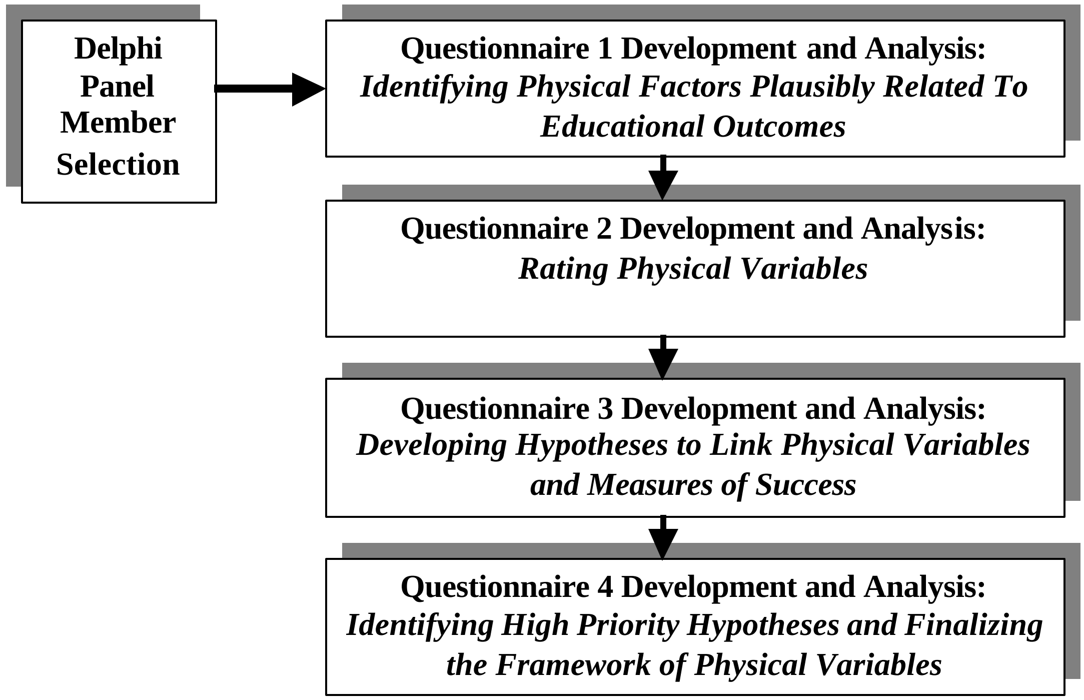


Figure 5.1 Overall Approach Using the Delphi Method

Delphi Panel Member Selection

First, Delphi panel members were selected for this study based on a purposive sampling methodology. That is, only researchers who have experience with studies regarding the effects of physical school conditions on students or teachers were included. A list of potential Delphi panel members was derived from the literature, using the same twenty-seven sources utilized in Phase II (Table 4.2). Several of these individuals could not be located, at least one was retired, and one was no longer actively involved with SFE research. Therefore, in order to increase the number of potential Delphi panel members, two experienced researchers were asked to provide recommendations of other qualified individuals. Each potential panel member was contacted by phone, whenever possible, in order to explain the study and invite the person to participate. An E-mail message to all potential panel members served as the "official" invitation to join. A copy of the invitation is included in Appendix E. An attempt was made to contact a total of thirty-four researchers to invite them to participate. Sixteen of those agreed, with one additional member deciding to participate after Questionnaire 1 was completed, for a total of seventeen panel members as potential respondents to Questionnaires 2 - 4. Among these seventeen panel members, thirteen hold a Ph.D., two hold an Ed.D., and two hold Master's degrees. All but two are currently involved with research or consulting related to school facilities, and the other two have previous experience. Among these researchers, most have published at least one book, peer-reviewed article, or doctoral dissertation related to school facilities. The others have a great deal of professional experience. In order to preserve anonymity of the participants, additional demographic information has not been provided.

Questionnaire 1: Identifying Physical Factors Plausibly Related to Educational Outcomes

The following sections describe how Questionnaire 1 was developed and how the Delphi panel members added to the original list of physical variables.

Questionnaire 1 development

The purpose of Questionnaire 1 was to identify a list of physical factors in schools that may affect educational outcomes. Delphi panel members were provided with a list of several items derived from the literature to seed this brainstorming exercise. The original list is shown in Table 5.1. The actual questionnaire sent to panel members is located in Appendix F.

Table 5.1. Original Brainstorming Concept List Based on the Literature Analysis

Physical Variables from Literature (Listed Alphabetically)		
Acoustics	Aesthetics and appearance	Age of the school building
Aircraft noise	Animal life on premises	Building maintenance
Building renovations	Class size	Classroom adaptability
Climate control	Daylighting	Full-spectrum lighting
Green areas/living views	Indoor air quality	Natural ventilation
Outdoor rooms or spaces	Perceived quality of classroom's physical environment	Presence of absence of fluorescent lighting
Presence or absence of air conditioning	Presence or absence of carpet	School building condition
School enrollment/size (not square footage)	Sensory stimulation	Site size
Thermal factors	Type of air conditioning	Type of artificial lighting
Underground facilities	Visual factors (broader than just lighting conditions, such as contrast between print and paper)	Visual stimulation
Wall color	Windows (presence or absence, type)	

Questionnaire 1 results

Sixteen panel members (100%) responded to Questionnaire 1 by adding items to the list in Table 5.1. Table 5.2 lists the resulting set of physical factors identified. Although several panel members suggested deleting some of the items on the original list, none were deleted since the group would have the opportunity to rate those as unimportant in Questionnaire 2 and since the Delphi method does not recommend a maximum number of items to include in a questionnaire.

Table 5.2. Resulting List of Physical Variables

Physical Variables Identified (listed alphabetically)
Absence of “departments”
Absence of mold
Access to resources and retrieval of information through technology and equipment (phones, copiers, fax, web—especially important if students are working with business and community partners in producing "real world" solutions)
Access to technology
Acoustic privacy from other groups
Acoustical environment
Adequacy of student personal storage
Adequate and adjacent storage and access to supplies
Adequate and well placed electrical outlets
Adequate physical ed facilities
Adequate supply storage space
Adequate work surfaces of different heights, sizes, and shapes to support work
Adult-student spatial integration
Appropriate commons for age group
Appropriateness of furniture (chairs, stools, desks/tables) for the task
Appropriateness of spaces to age group
Areas for 1 on 1, small and large group activities
Autonomous access to computer and library materials
Autonomy of access to group work area
Autonomy over time
Building flexibility
Building of niches
Child’s perceived safety while in school (from forces outside and within the school)
Circulation spaces and patterns that do not force hundreds or thousands of students into narrow, long spaces lined with lockers---these traditional spaces can foster aggression and hostility
Classroom flexibility
Classroom furniture
Counselors among the students
Crowdedness or spaciousness
Design features such as science laboratories, music rooms
Design for school safety
Ease of movement within building
Faculty collaborative space
Flexibility of group sizes
Flexible spaces
Fluidity of seating and work surface arrangements
Food service capabilities
Freedom of access and departure to school grounds
Grade configuration “Green” cleaning fluids (reduces voc)
Incorporation of student work into design of the school building
Individual workspace
Informal learning spaces where students, teachers, and staff can continue learning beyond the confines of the "classrooms"
Integration of culture into the educational facility design
Internal noise
Internet access (which, of course, implies computer presence)
Issues of scale in relation to various ages
Learning spaces out in the community—shared use of libraries, physical fitness, museums, internships within businesses and agencies, etc.
Legibility of the building
Lighting
Lockable, personalized storage
Maintenance of student toilets
Multiple access points and time availability to food and beverages
Outdoor learning spaces
Overcrowded conditions
Ownership and control over space
Personalization of the classrooms (students’ sense of ownership reflected in the facility)
“Philosopher’s chair”: constant, immediate access to intellectual advice. Implies faculty offices with the ability to house one or a handful of visiting students
Safety considerations
Scale of spaces
School facility integrated into community
School location
School size
School size
Seating configurations
Security
Sensory stimulation
Shape of room
Shared spaces
Sight lines within building
Signage
SizeSmall business incubator space
Small schools (not small classes)
Social spaces
Space for collaboration
Spaces for students to personalize
Spaces that support and provide for the following: Visibility of the learning process itself through the use of interior windows (we tend to keep learning hidden behind walls and closed doors); Different teaching and learning styles; Small learning communities and teams; Design, production, and testing and evaluation, and application of products; Practice and presentation of acquired knowledge, skills, and abilities; Display space and studios for ideas, processes, projects, and products
Spaces that support and provide the following: sense of community; sense of connection; sense of responsibility; sense of ownership; sense of pride; sense of trust; sense of safety
Square foot per child in the classroom
Square footage
Student "owned or programmed" space
Student accessible files
Student individual or team workstations
Sustainable design
Tack surfaces to post ideas, track learning systems, display work

Table 5.2. (cont'd).

Classroom shape	Presentation area	Task lighting
Cleanliness of the building	Privacy	Technology in classrooms; school
Color	Professional space for teachers	Telephones in classroom
Comfortable, flexible furniture	Professional spaces (offices, conference rooms, professional libraries, workrooms, lounges, etc.)	Thermal comfort
Community use of facility – partnerships	Prototype school building vs. non-prototype	Thermal environment control
Community, business, volunteer, and parent space within the facilities	Quality of social spaces	Town square
Condition of wall covering (paint peeling? Plaster deteriorating or cracked? Walls stained with water? Old paint?	Quiet, reflection space	Traffic flow
Conference spaces	Relationship of spaces within building	Visitors easily accommodated (parking, access, work areas)
Convenient storage of collective projects in process	Room shape	Visual and actual access to teachers, counselors, and staff throughout the facilities
		Visual and actual access to the outdoors
		Wayfinding

The Delphi panel members expanded the original list of thirty-two physical variables to 114 items. In Questionnaire II, they rated each of these items to indicate how important they perceive it is with respect to understanding links to educational outcomes.

Questionnaire 2: Rating Physical Factors

The following sections describe how Questionnaire 2 was developed using the data acquired from Questionnaire 1, as well as the results from Questionnaire 2.

Questionnaire 2 development

The purpose of Questionnaire 2 was for the Delphi panel members to rate the importance of the physical variables they identified in Questionnaire 1. Prior to the development of Questionnaire 2, the resulting list of physical variables plausibly related to educational outcomes in Table 5.2 was sorted into a hierarchical structure called the *Framework for Physical Factors Plausibly Related to Measures of Success*, hereafter referred to as the Framework (see Appendix G). The purpose of this Framework was two-fold: first to provide an organizational structure to simplify the rating task of

Questionnaire 2, and secondly to develop a structure for describing the final set of research priorities. There are three levels in this hierarchy - Physical Factors, Elements, and Items (broadest to most narrow). The categories at the Physical Factors level were developed by beginning with some of the aspects of environmental quality identified by Lackney (1996) and broad categories of variables identified by one of the Delphi panel member in his response to Questionnaire 1. However, these were modified and additional categories were developed to better suit the data obtained in Questionnaire 1. Two researchers worked together to attempt to develop a framework that would be meaningful to the Delphi panel. The specific categories in the Framework evolved as Delphi panel members commented on its contents and the labels given to the items, elements, and physical factors in later questionnaires. After Questionnaire 1, the category for Physical Factors included the following: Functionality (e.g., crowdedness or spaciousness and flexibility); Comfort, Health & Safety (e.g., visual comfort and indoor air quality); Aesthetics & Appearance (e.g., sensory stimulation); and Resources (e.g., community and technology resources).

Once the physical variables had been identified, Questionnaire 2 asked the Delphi panel members to rate the importance of those variables in terms of studying links to educational outcomes. Questionnaire 2 was developed using Free Online Surveys, a service that allows the user to create questionnaires on line, view results, and download responses into a spreadsheet program such as Microsoft Excel. With the Physical Factors, Elements, and Items sorted according to the developed Framework, each panel member was asked to complete two types of tasks, in the following order:

1. Task I: Rate each physical item according to its importance.
    - 1 = Not important
    - 2 = Somewhat important: Plausibly affects educational outcomes, but little to no research-based evidence exists
    - 3 = Important: Some evidence suggests it affects educational outcomes, but we still don't understand those effects well
    - 4 = Very important: Strong evidence exists, but we still don't understand those effects well

2. Task II: Relatively rate the Elements within each Physical Factor category by distributing one hundred points among those Elements to indicate relative importance.

Panel members were also asked to provide written comments about any of the physical variables or the Framework into which they had been organized (e.g., elaborate on why the variable may be important or to recommend that it be included under a different Element). A copy of Questionnaire 2 is located in Appendix H.

Questionnaire 2 results

Sixteen (ninety-four percent) panel members responded to Questionnaire 2, and the results are located in Appendix I. The top rated thirty-eight physical items (rated 3.2 or higher) are listed in Table 5.2. For the purpose of this study, a rating of 3.2 was used as a cut-off to identify the highest rated items, both for physical items and measures of success (although somewhat arbitrary, it was used consistently for both physical items in this phase and measures of success in Phase II).

Table 5.2. Top Rated (3.2 or Higher) Physical Items Plausibly Related to Educational Outcomes

Physical Variables	Avg Rating	Std Dev
Child's perceived safety	3.94	0.25
Overcrowded conditions (possibly determined by % capacity for school achieved, square foot per child in the classroom)	3.88	0.34
Natural lighting (e.g., windows, clerestories, skylights)	3.88	0.34
Presence or absence of pollutants indoors (e.g., mold, VOCs)	3.81	0.40
Autonomous access to computer and library materials	3.81	0.40
Interior noise (e.g., ambient, inside the learning environment)	3.69	0.48
Adequate ventilation	3.69	0.48
External noise (e.g., aircraft, highway)	3.63	0.50
Perceived quality of learning environment conditions	3.63	0.50
Appearance of walls (e.g., deteriorating plaster, water stains, frequency of painting)	3.63	0.50
Electric lighting (overhead, task)	3.56	0.51
Air-conditioning (e.g., presence, type)	3.56	0.51
Heating	3.56	0.51
Perceived cleanliness (may be affected by condition of student toilets, etc.)	3.56	0.51
Internet access	3.56	0.73
Science laboratories	3.53	0.52
Views to the outside	3.50	0.73
Individual control over thermal conditions (e.g., ventilation, temperature)	3.50	0.82
Counselors among students (college and career advice available without special trip through unwelcoming administrative territory)	3.50	0.65
Cleanliness	3.47	0.64
Visual conditions that affect occupants' ability to read and see comfortably such as glare, contrast between print and paper, etc.	3.46	0.52
Seating (comfortable and flexible, allows different seating configurations)	3.44	0.51
Faculty collaborative space	3.40	0.91
Learning environment (e.g., walls, equipment)	3.38	0.72
Building improvements/modernization	3.38	0.72
Team workstations/shared spaces	3.33	0.62
Conference spaces	3.33	0.49
Accessible phone, copiers, fax – especially important if students are working with business and community partners in producing "real world" solutions	3.33	0.72
Fluidity of seating and work surfaces to meet shifting and immediate needs	3.31	0.87
Spaces for quiet reflection (however created – furnishings, walls, doors, etc.) for both students and faculty	3.31	0.87

Table 5.2. (cont'd).

Physical Variables	Avg Rating	Std Dev
Informal learning spaces where students, teachers, and staff can continue learning beyond the confines of the "classroom"	3.31	0.70
Control over interior thermal, visual and acoustical conditions	3.31	0.70
Adult-student spatial integration that keeps teachers from retreating into adult "ghettos" where they never have to contact kids, and into which kids are not welcomed	3.29	0.73
Display space and studios for ideas, processes, projects and products (including tack surfaces)	3.27	0.70
Learning environment size (square footage)	3.27	0.70
Acoustic privacy from other groups	3.25	0.68
Telephones in classroom	3.21	1.05
Individual workspace (student "owned," allows a quiet home base, control of the modes of work)	3.20	0.68

Although the Delphi panel members were asked to brainstorm "physical factors", there were some variables listed that were not physical, but rather a response to some physical variables (e.g., child's perceived safety, perceived cleanliness). It is important to note that although panel members were asked in Questionnaire 2 to "respond only to the questions that you are comfortable answering, based on your personal knowledge and experience", some of their responses were based on their perceptions without any support from the literature. One panel member commented, "I am not sure of academic research on many of these specific issues, but this is my perception of the importance of these."

In addition to panel member ratings, comments were also received (e.g., the meaning of "site" and "school building" a bit vague... may be helpful to have examples). These comments (Appendix J) led to modifications of the Framework. The revised version of the Framework is shown in Appendix K.

Questionnaire 3: Developing Hypotheses to Link Physical Factors and Measures of Success

The following sections describe how Questionnaire was developed and the findings that resulted.

Questionnaire 3 development

The purpose of Questionnaire 3 was to have the Delphi panel members develop hypotheses to represent plausible relationships between the physical factors (identified by the Delphi panel) and measures of success (identified by educators in Phase II, see Chapter 4). The panel members were first asked to rate their own level of knowledge and experience for each physical item, using the following scale:

1 = Not experienced enough to suggest links to educational outcomes

2

3 = Familiar with this area at a general level

4

5 = Active researcher in this area

When writing hypotheses, the Delphi panel members were asked to focus on those physical factors that they, as a group, rated as important (average importance rating of 3.2 or higher) and with which they rated themselves a 3, 4, or 5. However, they could write hypotheses for any of the physical items. Similarly, they were asked to focus on those measures of success with an average group importance rating of 3.2 or higher (as rated by the group of educators). The panel members were encouraged to include mediators and moderators in their hypotheses, where applicable. ***Mediators*** are those variables that interpret or explain relationships between independent and dependent variables, whereas ***moderators*** are variables that interact with independent variables to influence the outcome (Evans and Lepore, 1997). For example, daylighting may induce a more positive mood, thereby improving test scores. In this case, a more positive mood is a mediator variable. If the effect is more prominent among those of lower socio-economic status (SES), then SES is a moderator.

Questionnaire 3 (Appendix L) was sent to panel members by e-mail in an Excel format and returned to the researcher in the same manner.

Questionnaire 3 results

The return rate for Questionnaire 3 was lower than desired, as only ten out of seventeen were returned (fifty-nine percent). This questionnaire required more time to complete than the other two questionnaires and at least two researchers reported that it took several hours to complete it. Panel members submitted a total of 107 hypotheses (Appendix M, listed by physical factor). Some of the hypotheses received were not written in the form of a testable hypothesis. While some of these were omitted or modified (see Questionnaire 4 development section regarding how these were treated), most of the hypotheses were not modified before using them in Questionnaire 4. A hypothesis should be a testable statement that predicts a relationship between variables. Also many of the hypotheses were complex, including several different relationships between variables.

Several types of analyses of these hypotheses were conducted in anticipation of developing a broad model of the relationships between physical factors and measures of success. First, the hypotheses were broken down into independent variables, moderators, mediators, and dependent variables. In many cases, a single hypothesis could be broken down into multiple hypotheses using this approach. Then, these individual variables were printed on index cards and posted on a large wall (Figure 5.2). The relationships were shown using arrows between the variables. Unfortunately, there were so many different relationships that grouping them into a model during this stage was not helpful, as too much specific information would be lost. Also, by grouping the variables and showing relationships between the groups, relationships emerge that were not suggested by panel members – relationships for which there is no basis to assume that they plausibly exist. Therefore, the idea of developing a model to represent the 107 hypotheses was not feasible. The number of hypotheses on which to focus was narrowed in Questionnaire 4.

Figure 5.2. Attempting to Model the Relationships

This analysis did reveal some interesting findings, however. The Delphi panel members acknowledged the need to study not just the correlations between specific independent and dependent variables, but also the mediators that explain those relationships. There were several types of mediators that were most prevalent among the hypotheses. Most notable were student behavior, and student and teacher attitudes. Other mediators that appeared in several of the hypotheses were social interaction/social development, and health-related issues. The dependent variables that were most often included in the hypotheses were achievement (by far the most common), satisfaction (students, teachers, and parents), and other teacher/administrator variables (e.g., professional development, absenteeism). The researchers did consider outcome variables that are important to educators. If studied, research findings are likely to be relevant to educators and other school stakeholders, and therefore more likely to be utilized.

In addition to the responses for Questionnaire 3, two panel members provided feedback on the second version of the Framework (see Appendix K). These comments (acquired in the form of e-mail messages) were the basis of modifications resulting in the third version of the Framework (Appendix N), which was used in Questionnaire 4.

Questionnaire 4: Identifying High Priority Hypotheses and Finalizing the Framework

Once the Delphi panel members had developed a set of 107 hypotheses, too many to include within a set of research priorities, they were then asked (in Questionnaire 4) to narrow this set by selecting those that are most important. Also, they were asked to provide comments for finalizing the Framework. The development of Questionnaire 4 and the results are provided in the following sections.

Questionnaire 4 development

The purpose of Questionnaire 4 was two-fold: 1) to narrow the list of hypotheses to a more manageable size in order to identify those that are the top priority for the Delphi panel; and 2) to finalize the Framework. Some of the 107 hypotheses were redundant or did not clearly state relationships between variables; therefore, several hypotheses were omitted from the original list. This shortened list of ninety-eight hypotheses was used in Questionnaire 4. The omitted hypotheses are listed in Table 5.3. Also, three hypotheses were reworded in the final list (see Table 5.4).

Table 5.3. Hypotheses Omitted From the Original List Based on Their Similarity to Other Hypotheses

OMITTED HYPOTHESES	Similar To or Included In This Hypothesis (as written by panel member)
Overcrowding leads to poorer performance	Students in over-utilized buildings will score lower on measures of student performance and have lower attendance rates than students in properly utilized buildings.
(Re: overcrowded conditions) ON-task behavior is a key indicator of learning, and discipline time detracts from this. Also one on one teaching is important for kids who do not get one on one at home	A learning space that is too small for the number of occupants (i.e., feels "overcrowded) will result in adverse behavior for all involved acting as a mediating variable affecting a host of academic and teacher job satisfaction related measures.
Students in buildings that have daylighting features will perform higher on measures of achievement than will students in buildings that do not have such features.	Students in daylit classrooms will score higher in achievement tests than students in classrooms without natural daylight. Daylit classrooms will experience lower absentee rates than non-daylit classrooms. Teachers in daylit classrooms will express higher job satisfaction than teachers in non-daylit classrooms. Daylit classrooms will experience fewer student suspensions than non-daylit classrooms.
(Re: cleanliness and on-task behavior/teacher perception) Broken window theory- disorderliness encourages more [disorderliness]	Schools that are not clean or aesthetically attractive will have higher rates of student discipline problems than schools that are attractive, well kept and clean.
(Re: AC and on-task behavior/teacher perception) Most of us don't function well in heat	Students in classrooms without air conditioning (at higher temperatures) will experience lower test scores, more behavior problems, higher absentee rates than students in classrooms with AC.
(Re: Ind. control over thermal conditions and student achievement) Students who are hot or cold have a difficult time focusing on classroom work	Being able to modify or control the ambient conditions in the learning environment improves learning.
(Re: Visual conditions that affect occupants' ability to read and see comfortably such as glare, contrast between print and paper, etc.) Kids can differ greatly on sensitivity to this kind of stuff	Students in buildings that have good lighting will perform higher on measures of achievement than will students in classrooms that have poor lighting.

Table 5.3. (cont'd).

OMITTED HYPOTHESES	Similar To or Included In This Hypothesis (as written by panel member)
(Re: faculty collaborative space and outcome measures "Teacher perception, number of contacts with other teachers, ideas from other teachers") Collaboration is important	The presence of faculty collaborative space, when combined with a school schedule and culture that makes its use the norm, will have countless benefits. Teachers will be more supported by their peers and administrators, and new teachers will be mentored more authentically, with greater participation in professional development. Teacher satisfaction will rise, and faculty attrition and absences will both be reduced. Because teachers will be able to collaborate over difficulties of specific students, those students will be more productive, have better attitudes, and be socially supported (all increasing parental satisfaction and reducing student transience).
(Re: Control over interior thermal, visual and acoustical conditions and outcome measures "Observation of on-task behavior, teacher perception") Sensitivity of teachers and kids to different conditions	Adequate control of building systems promotes (mediates) general teacher job satisfaction measures and to some degree moderates student performance.

Table 5.4. Reworded Hypotheses

Original Hypothesis	Re-worded Hypotheses	Reason for Rewording
Might help with discipline and order	Spaces for quiet reflection improve order and reduce disciplinary problems	Original did not specify relationships between variables, although this became clear by examining the original questionnaire
School maintenance can influence students' attitudes toward their school and subsequently vandalism	School maintenance influences students' attitudes toward their school (including pride about their school) and subsequently vandalism	To combine with the submitted hypothesis: "Perceived cleanliness can affect student's pride in their school and reduce vandalism"
I think ease of parental contact is important, as well as efficiency in doing other school related business. Use by students as a resource may also be important. Cell phones should not be overlooked as a teacher efficiency device	Telephones in the classroom increase the number of parent contacts	Clarify relationship between physical item and measure of success from the two lists.

Questionnaire 4 contained two parts – Questionnaires 4a and 4b. In Questionnaire 4a, the panel members identified their top priority hypotheses from the long list developed from Questionnaire 3. In Questionnaire 4b, panel members provided additional comments regarding the Framework. Questionnaire 4 (Appendix O) was sent out in an Excel spreadsheet and sent back in the same manner.

Questionnaire 4 results

As a result of Questionnaire 4, the list of 107 hypotheses was narrowed to just eleven top-priority hypotheses and the Framework was modified to address researcher comments. The results from Questionnaires 4a and 4b are presented below.

Questionnaire 4a Results: Selecting the Top Ten Hypotheses

Each panel member selected the top ten hypotheses that they believed should be part of a research agenda (studied first). Only ten panel members (fifty-nine percent) responded to Questionnaire 4a. Sixty (sixty-one percent) of the hypotheses were selected by at least one panel member (Appendix P). However, the number of hypotheses for which there was agreement (selected by 3 or more Delphi panel members) is only eleven. These eleven hypotheses (Table 5.5 are those that have become part of the recommended research priorities.

Table 5.5. Hypotheses Selected by Three or More Respondents

Physical Item/Hypothesis	Selected By	Avg Group Rating[1]	Std Dev
The availability for students to work comfortably and productively in teams will increase the range of opportunities for both academic and social growth. Students will be more positive about their school, feel more socially connected, and reduce off-task time through ease of using team-based environments. Faculty and parents will both report increased satisfaction with student learning and with the school environment.	6	3.33	.62
Circulation spaces designed with niches, benches, seating areas, natural light will provide opportunities for students and teachers to informally interact as they move through the building that may support an improved social climate and culture and build social capital within the school that will overtime lead to the academic growth of students, greater attendance by students, teacher/administrative retention, school connectedness, affective performance, as well as create a student friendly environment.	4	NR	NR
Students in over-utilized buildings will score lower on measures of student performance and have lower attendance rates than students in properly utilized buildings.	4	3.88	.34
The presence of faculty collaborative space, when combined with a school schedule and culture that makes its use the norm, will have countless benefits. Teachers will be more supported by their peers and administrators, and new teachers will be mentored more authentically, with greater participation in professional development. Teacher satisfaction will rise, and faculty attrition and absences will both be reduced. Because teachers will be able to collaborate over difficulties of specific students, those students will be more productive, have better attitudes, and be socially supported (all increasing parental satisfaction and reducing student transience).	4	3.40	.91
Collaborative work spaces provide an opportunity for positive interaction among teachers helping to build an interactive learning culture that improves overall student academic achievement and teacher job satisfaction.	4	3.40	.91
The ability for students and faculty alike to find and take advantage of private, quiet space will improve both satisfaction and performance among both groups. Student social development and general affect will be improved through the ability to self-regulate social interaction, and off-task behavior will be reduced through providing quiet space for individual and reflective work.	4	3.31	.87
Students in daylit classrooms will score higher in achievement tests than students in classrooms without natural daylight. Daylit classrooms will experience lower absentee rates than non-daylit classrooms. Teachers in daylit classrooms will express higher job satisfaction than teachers in non-daylit classrooms. Daylit classrooms will experience fewer student suspensions than non-daylit classrooms.	3	3.88	.34

Table 5.5 (cont'd).

Physical Item/Hypothesis	Selected By	Avg Group Rating[1]	
Students in buildings that are well maintained will perform higher on measures of achievement than will students in poorly maintained buildings.	3	3.63	.50[2]
Students in well-maintained buildings of good quality will score higher in achievement tests than students in poor quality buildings. Disciplinary problems will be higher in poorly maintained buildings than in good or excellent school buildings. Poorly maintained buildings will experience higher absentee rates than good or excellent buildings.	3	3.38	.72[2]
If seating is easily manipulable to suit multiple pedagogic purposes, this will increase the range of classroom experiences that students and teachers can employ. This will increase the range of classroom experiences that students and teachers can employ. The broader possible range of pedagogical strategies will lead to increased student academic growth, and will also reduce off-task behavior stemming either from boredom or from working at cross-purposes to the demands/affordances of a static environment	3	3.44	.51
If the daily life of the school is well-integrated into the community, students will feel that their work is more meaningful, that the school is investing in their ongoing lives. Students will be more connected to the adult community around them, increasing their social development and reducing their transience. Local businesses will be more familiar with the students, more willing to engage them as customers and workers. Both students and parents will report increased satisfaction with the school.	3	3.07	.96

[1] This is the Average Group Rating of the physical item only as rated in Questionnaire 2. The standard deviation is in parentheses. NR = not rated.
[2] Although both of these hypotheses include the term "well-maintained," they were written by respondents with regard to two different physical items – quality of learning environment conditions (3.63) and building improvements (3.38). These hypotheses were combined in the final list of hypotheses to be included in the research priorities (Table 5.6).

Among the hypotheses selected by three or more panel members, all but one includes a physical item that was rated 3.2 or higher. Since the hypotheses as first written were sometimes too complex or not stated clearly enough to be testable, the high priority hypotheses were rewritten by the researcher conducting this study (Table 5.6). In Table 5.6, the independent and dependent variables, as well as the moderators and mediators for each hypothesis are also listed.

Table 5.6. Final Hypotheses of High Priority

Hypothesis	Independent Variables	Mediators (Me) and Moderators (Mo)	Dependent Variables
The provision of spaces where students can work in teams will increase opportunities to use a variety of pedagogical techniques, resulting in the students feeling more socially connected and greater satisfaction among teachers, students, and parents as compared to schools where students do not have spaces where they can work in teams.	Spaces for students to work in teams	Increased use of a variety of pedagogical techniques (Mo)	Student sense of being socially connected; student satisfaction; teacher satisfaction; parent satisfaction;
The provision of circulation spaces with niches, benches, seating areas and natural light provides opportunities for informal interaction among students and teachers, resulting in an improved social climate that will lead to a more student friendly environment, a greater sense of school connectedness, and improved student academic growth, student attendance, affective performance, and teacher retention when compared to school buildings without this type of circulation spaces	Circulation spaces with niches, benches, seating areas and natural light	Informal interaction among students and teachers (Mo) Improved social climate (Mo)	Friendliness of the school environment; sense of school connectedness; student academic growth; student attendance; student affective performance; and teacher retention.
When school buildings are over-utilized, student attendance and student achievement will be lower than in school buildings that are not over-utilized	Utilization of school buildings		Attendance rates; student achievement
Teachers in schools with faculty collaborative space will feel more supported by their peers and administrators, experience greater satisfaction and greater participation in professional development than teachers in schools without faculty collaborative spaces.	Faculty collaborative spaces	Culture (in which use of faculty collaborative spaces is the norm (Mo))	Feelings of support (by peers and administrators; satisfaction; participation in professional development
Students in schools with faculty collaborative spaces will have better attitudes towards school, feel more socially supported, and experience improved academic achievement, reduced transience, and improved parent satisfaction when compared with students in schools without faculty collaborative spaces	Presence of Faculty collaborative spaces	Culture in which use of faculty collaborative spaces is the norm (Mo)	Student attitudes towards school; feelings of support (socially); academic achievement; student transience; parent satisfaction

Table 5.6 (cont'd).

Hypothesis	Independent Variables	Mediators (Me) and Moderators (Mo)	Dependent Variables
The provision of quiet, reflective space for students and teachers will result in improved student and teacher satisfaction, reduced off-task behavior and improved student social development and affective performance when compared with students and teachers in schools without private spaces for their use.	Quiet, reflective space	Ability to use private spaces (Mo); Ability to self-regulate social interaction (Me) [specifically for student social development and affective performance.	Student satisfaction; teacher satisfaction; off-task behavior; student social development; student affective performance
The provision of predominantly daylit classrooms is correlated with higher student academic achievement, lower absentee rates, fewer student suspensions and improved teacher satisfaction when compared with predominantly artificially lit classrooms	Daylit classrooms		Student academic achievement; absentee rates; student suspensions; and teacher satisfaction
Students in buildings that are well maintained and of good quality will perform higher on measures of achievement, create fewer disciplinary problems and have higher attendance rates than students in poorly maintained buildings and of poor quality.	Level of maintenance and building quality		Student academic achievement; absentee rates; and disciplinary problems
Students in classrooms with seating that can easily be manipulated to suit a variety of pedagogical teaching strategies will experience reduced off-task behavior and increased academic achievement when compared with students in more static classrooms	Manipulability of Seating	Use of a variety of pedagogical strategies (Mo); reduced boredom (Me) [specifically for off-task behavior]; reduced frustration due to flexibility of seating (Me) [specifically for off-task behavior]	Student academic achievement; off-task behavior
When the school is well-integrated into the community, students will feel more valued by the school and will experience greater social development, improved job opportunities, reduced transience and greater satisfaction. Parents will also be more satisfied when compared with parents of students in schools that are not well-integrated into the community.	School integrated into the community	Students more connected to their surrounding adult community (Me) [specifically for improved social development and reduced transience]; Local businesses more familiar with students	Student feeling about how they are valued by the school; Student social development; student transience; Willingness of local businesses to hire students; student satisfaction; parent satisfaction

Interestingly, although most of the Comfort, Health and Safety items were rated as important in Questionnaire 2, only one of those (daylighting) appeared in the final list of hypotheses. Although panel members did not comment on this, it is plausible that they perceive these to be less important to study with respect to educational outcomes because school designers and operators are already aware that visual, acoustical, and thermal conditions need to be adequate and comfortable and they are striving to provide appropriate ambient conditions (although many schools are not comfortable and lack sufficient ventilation, appropriate lighting, etc.). However, if all of the hypotheses selected by two or more of the Delphi panel members (rather than three or more) were included in the list of priority hypotheses, two additional ones would include physical variables related to Comfort, Health & Safety. These two hypotheses address the ambient conditions related to poor indoor air quality and excessive internal noise. If the high priority hypotheses were based on selection by two or more Delphi panel members, rather than three, there would be an additional twenty hypotheses included in the research priorities (see Appendix P). These hypotheses cover a range of physical variables such as: views to the outside; a combination of individual student workspace, spaces for students to personalize, and lockable personal storage; shape of the learning environment; class size, and several others.

Questionnaire 4b Results: Commenting on the Framework

Only nine panel members responded to Questionnaire 4b. While some comments were rather extensive, others were very brief. Two respondents commented that such a Framework is not useful to researchers because it seems like a "hodgepodge laundry list" without any link to theory development or because it includes "non-intrinsic items that …

have nothing to do with how students perform or how successful students or the school is." Other researchers commented via e-mail that the Framework is valuable, such as one who commented, "You've done a remarkable job pulling together lots of indicators"(personal communication, July 15, 2003). Most of the comments specifically addressed changes in the wording of the Factors, Elements, or Items or moving Items or Elements from one category to another. The summary of all comments received has been included in Appendix Q.

Based on all of the comments received for Questionnaire 4b, the Framework was modified in order to develop a Framework that logically represents the hierarchy of physical attributes that may affect measures of success. All of the comments were not incorporated, although most of them were used to shape the Framework into its final form. Although the entire list of items in the Framework will not be studied in the near future, it provides a structure for organizing these attributes. The Framework confirms that the SFE studies conducted to date have addressed only a small subset of those physical attributes that may affect teacher and student success. The final proposed Framework is presented in Table 5.7.

Table 5.7. Framework of Physical Variables Plausibly Related to Educational Outcomes

FACTOR	ELEMENT	ITEM
FUNCTIONALITY	***Building Legibility***	Signage
		Relationship and visibility of spaces within building (i.e., how spaces for different types of activities are interconnected)
		Color and lighting
		Floor plan layout
		Scale of building elements relative to one another
		Interior materials
		Exterior materials
	Spatial Features	"Schools within a school": learning "houses" with clear, identifiable spaces if large school
		Learning environment geometric shape (e.g., fat-L, square, rectangular, changeable)
		Academic Grade configuration (the manner in which grade levels are organized into a single school, e.g. K-3, K-5, 9-12, etc.)
		Informal gathering spaces
		A building of niches (allows many small groups to claim space and meet in regular locations)
		A town square (large area all pass through)
		Centralized vs decentralized offices
		Location of noisy classes, similar classes (e.g., distribute or cluster science classrooms), etc. relative to one another
	Resource Spaces	Library or multiple spaces from where information can be retrieved
		Music rooms
		Creativity studios--art, sound, graphic
		Science laboratories
		Physical education facilities
		Spaces to conceive, design, build, test, and evaluate projects
		Presentation space--small and large
		Food service areas (location and accessibility)
		Outdoor learning spaces (natural, man-made) - availability and their location
		Conference and meeting spaces
		Professional spaces for teachers (including work rooms, lounges, offices, professional library)
	Size	Size of school grounds
		School building size (e.g., building square footage)
		Learning environment size (e.g., classroom square footage)

Table 5.7 (cont'd).

FUNCTIONALITY (cont'd)	***Size (cont'd)***	Size and shape of circulation spaces
		Storage for teaching/learning supplies
	Adaptability	Site – the grounds that surround a school building (refers to having a site that accommodates diverse activities and changing needs)
		School building or buildings (refers to the ability to add on or renovate to meet changing needs/ long-range planning)
		Learning environment (e.g., movable walls, portable equipment, etc)
		Furnishings (seating that is comfortable and accommodating; diverse work surfaces - heights, sizes and shapes)
		Task lighting (moveable)
	Density (crowdedness)	Over-utilization of school building
SOCIABILITY	***Personalization***	Infusion of community culture into the fabric of the building
		Incorporation of student work into the school building
		Facility needs to "fit" the community in design and scale and should have an identifiable and recognizable "front door"
		Space to keep personal items (e.g., coats, boots)
		Lockable, personalized storage
		Student accessible files (students create and maintain an individual learning plan, portfolio of learning evidence)
		Individual workspace (student "owned," allows a quiet home base, control of the modes of work)
		Spaces for students to personalize
	Privacy	Spaces for quiet reflection (however created – furnishings, walls, doors, etc.) for both students and faculty
	Collaboration and social interaction	Access to group work area (allows team members to work on projects as mood and/or opportunity strikes)
		Team workstations/shared spaces
		Spaces to accommodate different size groups
		Visible Presentation area – present acquired knowledge, skills and abilities
		Spaces for display of ideas, processes, projects and products
		Spaces for production: design, testing and evaluation, and application of products (student developed – even products to sell)
		Commons areas appropriate for age group
		Informal learning spaces where students, teachers, and staff can further learn beyond the confines of the "classroom"

Table 5.7 (cont'd).

SOCIABILITY (cont'd)	***Collaboration and social interaction (cont'd)***	Space supporting multi-disciplinary activities
		Faculty collaborative space
		Interior windows for viewing of instructional areas
COMFORT, HEALTH & SAFETY	***Acoustical comfort***	Interior noise (e.g., ambient, inside the learning environment)
		External noise (e.g., aircraft, highway)
		Acoustic privacy from other groups
		Individual control over acoustical conditions (e.g., closing of door and window)
	Visual comfort	Daylighting (e.g., windows, clerestories, skylights)
		Electric lighting (general, task)
		Visual conditions (glare, contrast between print and paper, etc.)
		Views to the outside
		Individual control over visual conditions (e.g., illumination level)
	Thermal comfort	Air-conditioning for cooling (e.g., presence, type)
		Heating
		Relative humidity
		Individual control over thermal conditions (e.g., ventilation, temperature)
	Indoor air quality	Adequate ventilation
		Presence or absence of pollutants indoors (e.g., mold, VOCs, etc.)
	Safety and security	Sight lines within building
		Child's perceived safety
		Telephones in classroom (serve as a back-up security device)
		Site safety (visible entries, site lighting, alarms, etc)
		Presence of school safety officers with easy access and visibility
		Presence of community, business, and parent partners and volunteers throughout the building to add extra sets of adult eyes and create that sense of "safe presence."
		Secure storage of collective projects in process
AESTHETICS & APPEARANCE	***Sensory stimulation***	Floor coverings
		Wall coverings or treatments
		Colors
		Ability to use music to stimulate thinking, reflection, or action
		Alternatives to the intercom system – ability to make announcements without "jarring" everyone's senses

Table 5.7 (cont'd).

AESTHETICS & APPEARANCE (cont'd)	***Maintenance***	Cleanliness (upkeep, sanitary conditions)
		Quality of learning environment conditions (appearance of furniture, walls, etc.; deteriorating plaster, water stains, paint condition)
		Age of the school building
		Building improvements/modernization
RESOURCES	***Community Resources***	Visitors easily accommodated (parking, access, work areas)
		Proximity of school building to community
		Space for community and business representatives, volunteers, and parents within the school
		Learning spaces within the community - shared spaces such as libraries, physical fitness centers, museums,
		Small business incubator space
	Technology Resources (students and staff)	Computers and Internet access (data ports, electric outlets, wireless technology, etc.)
		Accessible phone, copiers, fax – especially important if students are working with business and community partners in producing "real world" solutions
		School building as a teaching tool (e.g., observed power generation from solar panel)
	Human Resources (within the school)	Spatial integration of teachers, counselors and students for access to intellectual and career advice (advice is obtained without special trips through unwelcoming main administrative territory)

The development of the Framework was a complicated process of combining the comments of Delphi panel members into one final product. There were several panel members who did not comment on the Framework at all, and others who provided an abundance of comments, making their contribution more substantial than those who provided only a few. This Framework has not been presented here as an all-inclusive list of physical variables that may affect educational outcomes, nor one for which there is consensus among the participants. However, it may serve as a springboard for future discussion among SFE researchers.

Discussion

The use of the Delphi method to achieve the goals of Phase III was successful. However, several lessons emerged that may be used to improve a replication of this study with another group of researchers or enhance the application of the Delphi method for another similar purpose (see Appendix R).

In response to Questionnaire 2, the Delphi panel members were asked to rate each of the 114 physical variables they had identified. Thirty-eight of these variables received a group average rating of 3.2 or higher (out of four possible points). Of those, twelve (thirty-two percent) relate to ambient environmental conditions associated with lighting, thermal conditions, acoustics and indoor air quality. The Delphi panel recognized the importance of ambient conditions and their effects on school building occupants. However, only one of the final priority hypotheses includes ambient conditions (daylighting), suggesting that the panel members feel as though enough is known about how ambient conditions affect educational outcomes, or that school decision-makers are already aware of the need to provide adequate ambient conditions. Or, perhaps the method used in Phase III encouraged researchers to think beyond the traditional types of SFE relationships regarding the effects of lighting, temperature, or acoustics (even if they are not yet well-understood) and recommend that future work focus on a broader set of issues. Ambient conditions may be outside the areas of expertise of the Delphi panel members, or they may consider their effects to be a bit mundane when compared with socio-spatial factors that focus on programmatic issues (such as spaces to support pedagogy that encourages collaboration and social interaction) that may interest them more. This is not to suggest that the work of those, such as building technologist, who study the effects of ambient conditions on building occupants is not important. After all, ambient conditions have been shown to affect educational outcomes and there are still many unanswered questions about how or why these effects occur, particularly with respect to the physiological or psychophysical mechanisms involved.

There were five physical variables (rated 3.2 or higher) that were related to other facility maintenance issues, including: perceived quality of learning environment conditions; appearance of walls (e.g., water stains); perceived cleanliness and cleanliness (later combined into one); and building improvements/modernization. The remaining physical variables were related to a variety of topics, such as density, collaboration (e.g., faculty collaborative spaces, team workstations/shared spaces, conference spaces), privacy, adult-student interaction, and technology.

The Delphi study conducted in Phase III supports the argument that there is a lack of information regarding how schools affect educational outcomes. One panel member commented, “I can certainly agree with you that we do not know specific building components that contribute, or how much each building component contributes to the total learning of students" (anonymous, personal communication, May 14, 2003). Several experienced SFE researchers generated more than 100 hypotheses that they perceived as being important to become part of a research agenda (and studied first). Although these include the types of physical variables that occur commonly in the literature, such as ambient environmental conditions (e.g., thermal, acoustical, and lighting conditions), overall building quality and maintenance, school age, and class size, there were many hypotheses addressing a much broader set of physical attributes. These include: the presence of specific types of spaces (e.g., conference spaces, science labs, display spaces for student and teacher work, and outdoor learning spaces); spaces for teachers (e.g., faculty collaborative spaces, professional spaces such as private offices and work rooms); and spaces to promote social interaction among students, teachers, counselors, and local community members (e.g., informal learning spaces, team work areas, adult-student spatial integration, a location that is convenient to community resources, and counselors among students). The Delphi panel members recognized a need for research to investigate how physical spaces designed to encourage social interaction and collaboration affect students and teachers, a topic with very little coverage in the current SFE literature.

The Delphi panel members selected to participate in this study were purposively chosen, based on reputational case selection. Each member has published work in the area of school facility effects on educational outcomes and was invited to participate based on his or her expertise. If this study were repeated with an entirely different set of SFE researchers, it is unlikely that the same exact set of priority hypotheses would emerge. However, it is probable that the research priorities developed by another set of

SFE researchers would address the same broad areas including: Sociability; Functionality; Comfort, Health & Safety; Aesthetics & Appearance; and Resources as defined by the Framework developed in this study.

The panel members also developed several hypotheses that incorporated combinations of physical factors and mediating variables, indicating a need to approach SFE research from a more transactional perspective in which the broader context of the school environment is considered rather than simpler one-to-one, unidirectional relationships. For example, one panel member noted that although building age may be correlated with achievement, it is not very meaningful unless we “open up the Pandora’s box (black box) to look at the ecology of relationships to see that age probably is one of a bundle of variables that might influence a student.” One limitation of this study is that by asking the respondents to consider physical variables and outcome variables identified as important, it may have encouraged them to generate hypotheses that are more appropriate for univariate interactional types of research rather than transactional. However, by including mediating and moderating variables, the respondents did generate some rather complex hypotheses, such as, “a combination of individual student workspace, spaces for students to personalize and lockable personal storage will create a sense of ownership in students that may lead to better attitudes toward school and motivation to learn that will positively influence their performance, greater student attendance and overall success in school, socially and academically.” Testing this type of hypothesis would require a multivariate analysis that examined the effects of mediating variables.

The most important contribution of Phase III is the final ten hypotheses that combined the knowledge and experience of both educators and SFE researchers. These are included in the set of research priorities recommended in Chapter 6. In Chapter 6, the results of this phase were compared with the findings from the literature review (Phase I) and the concept mapping exercise with educators (Phase II). The high priority hypotheses seem to reflect some common trends in school design and include variables that may be considered “hot topics”. For example, there has been excitement regarding daylighting in the past few years because of the findings of the study by the Heschong Mahone Group (1999), and daylighting appears on the recommended list of research priorities. It is not surprising that the perceptions of the Delphi panel members seem to be affected by issues of the day (such as collaboration and flexibility, for example). However, it is surprising that a hypothesis regarding indoor air quality did not appear in the final list of priority hypotheses, since there has been much attention given to this issue (as described in Chapter 3) and the U.S. Environmental Protection Agency has developed a widely-distributed indoor air quality Toolkit for schools to help them identify and correct common indoor air quality problems. There may be some bias towards topics that the SFE researchers personally want to pursue in the future, although they did clearly consider outcome measures that are important to educators. The Delphi method used in this study encouraged participants to think beyond traditional lines of research, such as how thermal conditions are associated with performance of some type of task. The absence of these types of topics in the final set of research priorities does not diminish their importance, but SFE researchers are ready to pursue a broader set of issues.

While there is still much work to be done to further refine the hypotheses, generate buy-in from a larger audience of SFE researchers and school decision-makers, secure funding, and design appropriate studies to investigate these hypotheses, Phase III has provided an important basis for guiding future research.

CHAPTER 6

PHASE IV - RESEARCH PRIORITIES FOR UNDERSTANDING THE EFFECTS OF PHYSICAL VARIABLES ON EDUCATIONAL OUTCOMES

Purpose

Those who make decisions about school facilities – which schools to renovate, where to build new schools, what school designs to use, and how to maintain the facilities – play an important role in student education. Although there are likely several factors that affect whether or not school decision-makers incorporate research findings into the design and operation of school facilities, this study has shown that one reason is that there is a gap in knowledge about how school buildings impact educational outcomes. Although past research has shown correlations among various physical elements and educational outcomes, there are many other variables that are important to understand for which there is little or no data. Further, causal relationships are mostly unknown. *The purpose of this chapter is to compare the information gathered in the three inter-related studies of this dissertation research (the literature analysis; the identification of measures of student, school, and school district success; and the identification of physical variables likely to affect those measures of success) to identify knowledge gaps and to present a set of nine research priorities to guide future research, based on identified high priority hypotheses*. This chapter also describes the methodology used to identify knowledge gaps and research priorities and provides a discussion of each recommended research priority.

Methodology

The following sections describe the methodologies used to conduct a gap analysis to determine if important knowledge is missing from the literature and to identify research priorities.

Gap Analysis

To investigate whether or not there is a lack of knowledge in the field, a comparison of the findings from the literature analysis, the concept mapping exercises, and the Delphi study was conducted. The following tasks were performed:

1. Identify which of the *educational outcome variables* rated highly ($\geq$3.2) by the educators were also identified in the literature and which ones were not.
2. Identify which of the *physical variables* rated highly ($\geq$3.2) by the Delphi panel were also identified in the literature and which ones were not.

The method of analysis simply involved reviewing the variable ratings by the educators and Delphi panel members and determining whether or not those variables were included in Appendix A, the table that lists the variables studied in previous literature. The gap analysis supports the argument that important SFE knowledge is missing. The research priorities developed by the Delphi panel include several topics identified in the gap analysis.

Research Priorities

The selection of research priorities is based on the priority hypotheses developed by the Delphi panel (see Chapter 5). These hypotheses were developed through a series of questionnaires. The Delphi panel members, who were knowledgeable of the SFE literature, were asked to create hypotheses that included independent and dependent variables that were rated as important (by educators and themselves in Phases II and III). Then, they were asked to select from their list of more than 100 hypotheses those that they perceive to be the most important study first and which should become part of a research agenda. The hypotheses selected by three or more panel members (Table 5.6) became the high priority hypotheses on which the research priorities were based. The final section in this chapter presents a discussion of these research priorities.

Gap Analysis: A Comparison of Three Studies

A comparison of each of the three studies conducted for this dissertation has revealed that there are important gaps in the knowledge about how school facilities affect educational outcomes. A comparison of the educational outcomes that educators perceived to be important versus those that were included in the literature reviewed in Chapter 3 provides a list of several important (as perceived by educators) measures of student, school, and school district success that have not been addressed in previous SFE research. Additionally, there are physical variables that experienced researchers perceive to be plausibly related to those measures of success that have been overlooked in the literature. These are presented in the following sections.

Comparing the Literature With Educator Perceptions

During the brainstorming session in Phase II, the educators produced a rather lengthy list of measures of student, school, or school district success - many of which were not identified in the literature analysis. In fact, there were nineteen items that educators rated as important (3.2 or higher) that were not found in the literature. Also, there were twenty-two educational outcomes evaluated in the literature (reviewed in Chapter 3) that educators did not rate as highly important (below 3.2). This comparison is shown in Table 6.1 and suggests that researchers have not yet investigated how physical facilities affect many educational outcomes that are relevant to educators.

Nearly half of the items that have been overlooked in previous literature that are important to educators pertain to teachers and/or administrators, indicating that the SFE literature to date lacks information regarding measures of student, school, or school district success based on educator outcomes. Other types of measures that have not been the focus of SFE research pertain to local community resources, parents, and school climate.

The list of items from the literature that were not rated as important to monitor or otherwise track includes some items related to student behavior and academic achievement which are similar to other outcome measures that were rated as important. For instance, all health items on the original brainstorming list were either deleted or rated as unimportant by the educators. The educators did not provide any explanation for why they gave health variables such a low rating. It does not mean that they do not feel as though student health is not important, but they perceive it to be less important to monitor or otherwise track student health than the other types of outcome measures identified. This is interesting, given that providing healthy school environments is a primary focus of the high performance schools agenda. It suggests a disconnect between school research and the beneficiaries that research is designed to impact.

Table 6.1. Comparison of Measures of Student, School, or School District Success

Important[1] to Educators – Not in Literature	**In Literature – Not Highly Important[1] to Educators (avg rating)**
Community Business satisfaction with student employees and graduates	Blood pressure – deleted[2]
Community involvement	College-related variables *(such as admission to college)* (3.12)
General and Special Education Cohesiveness	Distraction - deleted
Graduation Test score performance (one specific type of achievement)	Dropout rate- deleted
Length of time 'in-country' for immigrant students	Graduates constructively employed - deleted
Multiple retentions	Health (1.49)
Parental Satisfaction	Intellectual performance - deleted
Staff development	Interpersonal relations with other students and school staff (3.06)
Student friendly environment	Level of extracurricular participation (2.35)
Student satisfaction with post secondary preparation	Occurrences of discipline consequences (3.0)
Student transience rate	Off-task behavior (2.82)
Support services are provided (paraprofessionals, secretarial, etc)	Retention *(students who have not dropped out of school)* (3.0)
Teacher mentoring	School district avg SAT mathematics score - deleted
Teacher support (i.e., induction program, availability of instructional leadership training, etc.)	School district avg SAT verbal score score - deleted
Teacher/administrator absentee rates	Social behavior problems - deleted
Teacher/administrator general levels of satisfaction	Student anxiety - deleted
Teacher/administrator levels of collaboration	Student self-concept (2.88)
Teacher/administrator participation in professional development	Student social development (3.0)
Teacher/administrator retention	Suspensions: in-school (2.88)
	Suspensions: out-of-school (2.94)
	Test characteristics *(high school proficiency test)* - deleted
	Well-being *(includes health symptoms)* - deleted

[1]Important to monitor or otherwise track

[2] Educators were allowed to recommend that items be deleted from the original brainstorming list, but were not required to discuss their reasoning explicitly.

Comparing the Literature With Delphi Panel Member Responses

A comparison of Delphi panel members' responses to the reviewed literature also shows that there are gaps in the literature to date. Twenty-two physical variables rated as important (3.2 or higher out of four) by the educators were not identified in the literature review in Chapter 3 (Table 6.2). However, there were only five items in the literature that were rated below a 3.2 by the Delphi panel. Among the physical items rated as important by the Delphi panel are several, such as those related to technology and safety, that are likely addressed in other bodies of literature, although they were not identified in the literature analysis for this study. For several of the highly rated physical variables, schools receive specific guidance from their districts, states, or other agencies. For example, minimum square footage (i.e., "learning environment/classroom size") is prescribed in educational specifications, but the literature reviewed did not identify benefits associated with specific square footage requirements for various types of learning spaces. The ambient environmental conditions listed in Table 6.2 include: heating; control over interior thermal, visual and acoustical conditions; and adequate ventilation. Of these, the American Society of Heating, Refrigeration and Air-Conditioning Engineers recommends specific ventilation rates for school environments, as well as comfortable temperature ranges for the heating and cooling seasons. There is available literature regarding occupants' ability to control interior ambient conditions in other types of buildings (e.g., commercial buildings), but it was outside the scope of this study to review them. There are several variables in Table 6.2 that pertain to collaboration and social interaction. None of the literature reviewed in Chapter 3 included these types of variables, indicating a need for research in this area.

Table 6.2. Comparison of Physical Variables

Rated as Important[1] by Delphi Panel (3.2 or Higher) – Not in Literature	In Literature – Not Rated as Important[1] by Delphi Panel[2]
Accessible phone, copiers, fax – especially important if students are working with business and community partners in producing "real world" solutions	Age of the school (2.63)
Acoustic privacy from other groups	Outdoor rooms or spaces (3.06)
Adequate ventilation	Sensory stimulation (no items under this category rated 3.2 or higher)
Adult-student spatial integration that keeps teachers from retreating into adult "ghettos" where they never have to contact kids, and into which kids are not welcomed	Site size (2.73)
Autonomous access to computer and library materials	Wall color (color, more generally = 2.63)
Child's perceived safety	
Cleanliness/perceived cleanliness	
Conference spaces	
Control over interior thermal, visual and acoustical conditions	
Counselors among students (college and career advice available without special trip through unwelcoming administrative territory)	
Display space and studios for ideas, processes, projects and products (including tack surfaces)	
Faculty collaborative space	
Fluidity of seating and work surfaces to meet shifting and immediate needs (subset of learning environment flexibility)	
Heating	
Individual workspace (student "owned," allows a quiet home base, control of the modes of work)	
Informal learning spaces where students, teachers, and staff can continue learning beyond the confines of the "classroom"	
Internet access	
Learning environment/classroom size (square footage)	
Overcrowded conditions	
Seating (comfortable and flexible, allows different seating configurations) NOTE: furniture arrangement is in literature	
Team workstations/shared spaces	
Telephones in classroom	

[1] Importance is based on the evidence regarding if or how the physical variable affects educational outcomes and whether it is important to study in the future

[2] Some physical items from the literature that were included on the original brainstorming list were not rated because they were modified or combined with other variables based on Delphi panel member comments in Questionnaire 1.

It is not surprising that there are only a few items from the literature that were not rated as important by the Delphi panel members, since these persons are intimately familiar with this body of literature. One of these items, “age of school building,” has been shown rather consistently in the literature to be associated with student achievement and attitudes. However, more than one Delphi panel member commented that age is *not* important if the school is well maintained and in good condition. Although the panel members did not rate “outdoor rooms and spaces” 3.2 or higher, its rating of 3.06 is respectable, reflecting a current trend in school design to provide outdoor spaces for environmental education and other uses. The fact that there were so many physical variables rated highly by the Delphi panel members (most of whom are authors of the reviewed literature) that were not included in the literature suggests that these may be topics of their current work yet to be published or ideas they have for future research.

As stated in Chapter 1, this study has investigated the possibility that a lack of knowledge (among other factors) has minimized the impact of current SFE research on the design and operation of school facilities. The gap analysis supports the argument that there are important gaps in current knowledge on this topic. The following research priorities are intended assist researchers with acquiring knowledge that is relevant to educators.

Research Priorities

One of the primary goals of this dissertation research was to develop a set of priorities to guide future SFE research that will be meaningful to researchers and practitioners (i.e., educators) alike. The nine research priorities are believed to reflect the concerns of both groups. These address the need to understand the effects of the following physical variables on a variety of educational outcomes:

- Student team work stations;
- Faculty collaborative spaces;
- Quiet, reflective spaces;
- Circulation spaces with niches, seating areas, and natural light;
- Adaptable seating;
- Daylit classrooms;
- Level of maintenance and building quality; and
- School integration into local community

This document does *not* recommend specific methodologies for tackling research questions. It is also outside the scope of this study to provide a detailed literature review of studies addressing each of the types of physical and outcome variables suggested for further study. The intent of this set of research priorities is to increase awareness of the necessity to conduct targeted research to better understand school facility effects and to help focus those efforts. Phases I through III built upon one another and culminated in a set of priority hypotheses, achieving an important goal of this research. These are presented as the research priorities for the SFE field.

The recommended research priorities are based on the priority hypotheses developed by the Delphi panel. Table 6.3 shows that thirteen of the fifteen education outcomes included in the priority hypotheses developed by the Delphi panel in this study were rated highly (3.2 or higher) by the educators. There is agreement between the Delphi panel and educators that these thirteen outcomes are important - important to monitor or otherwise track, and important to study with respect to the physical environment. Two of the three outcome measures that were included in the high priority hypotheses (developed by the Delphi panel) but not rated highly by educators were very similar to other items that *were* rated highly by the educators. The third item, “student social development” was rated 3.0, indicating that it is rather important to the educators as well as to the Delphi panel.

Table 6.3. Dependent Variables in High Priority Hypotheses

<table>
<tr><th>In High Priority Hypotheses AND Rated Highly By Educators</th><th>IN HIGH PRIORITY HYPOTHESES BUT NOT RATED HIGHLY BY EDUCATORS</th></tr>
<tr><td>Student outcomes
• Feelings of social support
• Student sense of being socially connected (i.e., school connectedness)
• Student attendance
• Student affective performance
• Academic achievement/growth
• Student attitudes towards school
• Student transience
• Student behavior/discipline
• Willingness of local businesses to hire students - similar to educator outcome measure “community business satisfaction with student employee and graduates”
Teacher outcomes
• Teacher retention
• Participation in professional development
Other outcomes
• Satisfaction (teacher, parent, and student) – educators did not rate student satisfaction in a general sense, but specifically “student satisfaction with post-secondary preparation”
• Friendliness of the school environment</td><td>• Teacher feelings of support (by peers and administrators) – Not an outcome specifically identified by educators. Related outcome measures included “support services provided (e.g., secretaries, paraprofessionals)” and “teacher support (i.e., induction program, availability of instructional leadership training, etc.),” both rated 3.29
• Student social development – rated 3.0 by educators (fairly important)
• Student sense of feeling valued by the school - Not an outcome specifically identified by educators. Related outcome measures include” student affective performance” and “school connectedness,” both rated 3.35</td></tr>
</table>

It is not surprising that the Delphi panel members developed hypotheses that include outcome measures that are important to educators. After all, they were encouraged to consider the measures of student, school, and school district success that were rated highly by educators, and this was one goal of the Delphi study. Panel members were also given the latitude to consider the entire list of outcome measures and their focus on those that were important to educators suggests their willingness to address research that will be relevant to this group of practitioners.

This study has taken one step in the direction towards a collaborative research approach, one where all parties equally participate in defining research problems and developing research strategies (Nyden & Wiewell, 1992). Further exploration may indicate that collaboration between SFE researchers and educators will provide the kinds of data that will interest school decision-makers and perhaps increase their utilization of research findings in the future to design and operate better schools. The research priorities are described below, categorized according to the Table 6.4.

Table 6.4. Categorization of Research Priorities

Categorization	Sub-Category	Research Priority
PROGRAMMATIC	***Sociability***	(1) Student team work stations
		(2) Faculty collaborative spaces
		(3) Quiet, reflective spaces
		(4) Circulation spaces
	Functionality	(5) Building utilization
		(6) Flexible seating
	Resources	(7) Community integration
AMBIENT	***Comfort, Health & Safety***	(8) Daylighting
	Aesthetics & Appearance	(9) Level of maintenance and building quality

Programmatic: Sociability

Research Priority 1: Effects of Student Team Work Stations

Hypothesis: The provision of spaces where students can work in teams will increase opportunities to use a variety of pedagogical techniques, resulting in the students feeling more socially connected and a greater satisfaction among teachers, students, and parents as compared to schools where students do not have spaces where they can work in teams.

There were two highly rated physical variables that promote collaboration in the priority hypotheses – the provision of team workstations for students to work in groups, and faculty collaborative spaces. There is little or no evidence about whether or not providing spaces for students to work in teams will actually increase the use of a variety of pedagogical strategies by teachers (a potential moderator). More than likely, many teachers will need to be retrained to use more collaborative pedagogical strategies. If they are trained and use these collaborative teaching techniques, it is plausible that students will feel more socially connected and that teachers, students and parents will experience greater satisfaction when compared to schools where students do not have spaces where they can work in teams. However, it is currently unknown whether or not this occurs. There were no studies identified as part of this study where "the provision of spaces where students can work in teams" has been operationalized. Realistically, any space with moveable desks and chairs could be made into a collaborative space. There are many more issues surrounding this concept than just whether or not students can work together at a table. Some Delphi panel members expressed a need for specified team work areas where students' work in progress is protected from vandalism, where they have acoustic privacy from other groups, and where they can easily share ideas. It is important for researchers to develop an operational definition of student team work areas that considers whether or not they are present and of good quality, as well as how if and how they are utilized. Similarly, operational definitions for the outcome variables are needed. Table 6.5 lists measures of the dependent variables used in previous studies evaluated in Chapter 3.

Table 6.5. Measurements of Variables for Research Priority 1

Variable	How Measured
Team work stations	• None identified
Satisfaction (teacher, parent and student)	• Student satisfaction was measured by Lindsay (1982), cited in Fowler (1995), by asking students how satisfied they were with required courses; Student and teacher satisfaction measured by Ahrentzen and Evans (1984) using a question on a questionnaire rating satisfaction with the classroom environment (5 point scale) • No measures of parental satisfaction in the reviewed studies
Student sense of being socially connected (i.e., school connectedness)	• McNeely et. al. (2002) used student surveys to solicit responses to 5 statement: 1) I feel close to the people at this school; 2) I feel like I am a part of this school; 3) I am happy to be at this school; 4) The teachers at this school treat students fairly; and 5) I feel safe in my school. A 5-point Likert scale was used (1=strongly agree, 5=strongly disagree). Summed scores were reverse-coded so that higher scores represented greater connectedness

Research Priority 2: Effects of Faculty Collaborative Spaces

Hypothesis 1: Teachers in schools with faculty collaborative spaces will feel more supported by their peers and administrators, experience greater satisfaction, and greater participation in professional development than teachers in schools without faculty collaborative spaces.

Hypothesis 2: Students in schools with faculty collaborative spaces will have better attitudes towards school, feel more socially supported, and experience improved academic achievement, reduced transience, and improved parent satisfaction when compared with students in schools without faculty collaborative spaces.

It is plausible that faculty collaborative spaces will provide several benefits for students and teachers alike, but there must be a culture in which the use of such spaces is the norm (a potential moderator). Similar to student team work stations, no studies were identified in this study in which faculty collaborative spaces have been operationalized. What are the components of adequate or good collaborative spaces for teachers? Do they need to have a phone line and Internet access? Perhaps comfortable seating areas and/or large work tables are necessary. There is more work to be done in order to measure the effects of collaborative spaces on teachers and students, both for the physical variables and for the outcome variables. Table 6.6 lists the variables from these hypotheses and how they have been measured in past studies, when available.

Table 6.6. Measurements of Variables for Research Priority 2

Variable	How Measured
Faculty collaborative work spaces	• None identified
Satisfaction (teacher and parent)	• Student satisfaction was measured by Lindsay (1982), cited in Fowler (1995), by asking students how satisfied they were with required courses; Student and teacher satisfaction measured by Ahrentzen and Evans (1984) using a question on a questionnaire rating satisfaction with the classroom environment (5 point scale) • No measures of parental satisfaction in the reviewed studies
Student attitudes towards their school	• Measured using pre-test and post-test scores on the "Our School Building Attitude Inventory" devised by Dr. Carroll McGuffy, U. GA (Chan, 1982); 6 items regarding student attitudes in the questionnaire used by Cheng (1984) for measuring student affective performance
Academic achievement	• Standardized tests used in the literature: Test of Academic Proficiency for grade 11, students' Iowa Test of Basic Skills, Comprehensive Tests of Basic Skills, Wisconsin Student Assessment System, Texas Assessment of Academic Skills, Stanford Achievement Test - 9, Arkansas Benchmark Test, Pupil Evaluation Program test, Minimum Basic Skill test, High School Proficiency Test • Performance tests in literature included: Embedded phoneme test (Fowler 1990), Woodcock Reading Mastery Test (Woodcock 1987)
Teacher feelings of support (by peers and administrators)	• None identified
Teacher satisfaction	• None identified
Participation in professional development	• None identified
Student feelings of support (socially)	• None identified
Student transience	• None identified

Research Priority 3: Effects of Quiet, Reflective Space

Hypothesis: The provision of quiet, reflective space for students and teachers will result in improved student and teacher satisfaction, reduced off-task behavior, and improved student social development and affective performance when compared with students and teachers in schools without private spaces for their use.

Most schools built in the past have provided very little privacy for students or teachers, although the trend is changing to some degree. It is not uncommon for a teacher to wait in line during her plan period to use the one phone in a private room to make a personal call. Students may only be able to find privacy in the restroom. Regardless of how the private spaces are created, if they exist it is essential that students and teachers be encouraged to use them. One must keep in mind, however, that there are sometimes competing interests between allowing privacy and maintaining control, with teachers perhaps having less control as student privacy increases. Researchers should focus some effort on determining if and how privacy amenities affect student attitude, behavior, achievement, social development, and sense of school connectedness. It will be important to observe whether or not students and teachers are encouraged and able to use private spaces (a potential moderator). The ability to regulate social interaction has been hypothesized as a partial mediator of the links between the presence of quiet, reflective spaces and desired educational outcomes. Table 6.7 lists the variables included in the hypothesis above have been measured in previously reviewed studies.

Table 6.7. Measurements of Variables for Research Priority 3

Variable	How Measured
Quiet, reflective spaces	• Desk type (shared or separate) and whether classroom had a secluded study space (physically distinct areas smaller in scale and size than the regular classroom, intended to accommodate only a few students (Ahrentzen & Evans, 1984)
Satisfaction (teacher and student)	• Student satisfaction was measured by Lindsay (1982), cited in Fowler (1995), by asking students how satisfied they were with required courses; Student and teacher satisfaction measured by Ahrentzen and Evans (1984) using a question on a questionnaire rating satisfaction with the classroom environment (5 point scale)
Off-task behavior	• Cameras made a photographs sequence of time-lapsed pictures (Ott, 1976);
Student affective performance	• Measured using a student self-report questionnaire: questionnaire using a 5-point scale included the following: self-concept (9 items), attitudes toward peers (5 items), attitudes toward school (6 items), attitudes toward teachers (5 items), self-efficacy of learning (10 items), feeling of homework overload (1 item), and intention to drop out (1 item) (Cheng, 1994)
Student social development	• None identified

Research Priority 4: Effects of Circulation Spaces with Niches, Seating Areas, and Natural Light

Hypothesis: The provision of circulation spaces with niches, seating areas, and natural light provides opportunities for informal interaction among students and teachers, resulting in an improved social climate that will lead to a more student-friendly environment, a greater sense of school connectedness, improved student academic growth, student attendance, affective performance, and teacher retention when compared to school buildings without this type of circulation spaces.

Circulation spaces received no attention in the literature evaluated in Chapter 3. However, there is a current trend to widen circulation spaces in schools to allow their use for learning activities. There was agreement among Delphi panel members in this study that is it important to evaluate if and how circulation spaces with niches, benches and other seating, and natural light affect educational outcomes. This hypothesis includes a complex set of relationships that approaches a more ecological research approach, but will be difficult to measure. It includes a moderator, whether or not more informal interaction occurs, that will modify the effects of these types of circulation spaces on the educational outcomes included. The trend to design areas for informal interaction is also occurring in the corporate arena to stimulate creative thinking among colleagues. The panel members hypothesized that an improved social climate is the mediator linking well-designed circulation spaces with improved educational outcomes. Previous measures for the outcome variables included in this hypothesis are listed in Table 6.8.

Table 6.8. Measurements of Variables for Research Priority 4

Variable	How Measured
Provision of circulation spaces with niches, seating areas, and natural light	• None identified
Academic achievement/growth	• Standardized tests used in the literature: Test of Academic Proficiency for grade 11, students' Iowa Test of Basic Skills, Comprehensive Tests of Basic Skills, Wisconsin Student Assessment System, Texas Assessment of Academic Skills, Stanford Achievement Test - 9, Arkansas Benchmark Test, Pupil Evaluation Program test, Minimum Basic Skill test, High School Proficiency Test • Performance tests in literature included: Embedded phoneme test (Fowler 1990), Woodcock Reading Mastery Test (Woodcock 1987)
Student attendance	• Measured as total days of attendance divided by total possible days of attendance (Lewis, 2001); Student attendance rate obtained from the Texas Education Agency's Division of Communications and Public Information (O'Neill & Oates, 2000); Attendance rates as reported by the principal (Lindsay, 1982 cited in Fowler, 1995)
Student affective performance	• Measured using a student self-report questionnaire: questionnaire using a 5-point scale included the following: self-concept (9 items), attitudes toward peers (5 items), attitudes toward school (6 items), attitudes toward teachers (5 items), self-efficacy of learning (10 items), feeling of homework overload (1 item), and intention to drop out (1 item) (Cheng, 1994)
School connectedness	• McNeely et. al. (2002) used student surveys to solicit responses to 5 statement: 1) I feel close to the people at this school; 2) I feel like I am a part of this school; 3) I am happy to be at this school; 4) The teachers at this school treat students fairly; and 5) I feel safe in my school. A 5-point Likert scale was used (1=strongly agree, 5=strongly disagree). Summed scores were reverse-coded so that higher scores represented greater connectedness
Teacher retention	• Measured using 3-year average teacher turnover rate. Obtained from the Texas Education Agency's Division of Communications and Public Information (O'Neill & Oates, 2000)
Friendliness of school environment	• None identified

Programmatic: Functionality

Research Priority 5: Effects of Over-Utilization of a School Building

Hypothesis: When school buildings are over-utilized, student attendance and student achievement will be lower than in school buildings that are not over-utilized.

Approximately 22% of public schools reported being overcrowded (in 1999), with 8% expressing that they were severely overcrowded (more than 25% above capacity) (U.S. Department of Education, 2001). There have been several studies focused on school size and class size. However, those studies do not usually include a measure of actual density (e.g., number of students per square foot of classroom space). The Delphi panel members recommended that density, particularly over-utilization of school spaces, be studied in the near-term, as it is plausibly related to both student attendance and student achievement. Table 6.9 lists related variables and how they have been measured.

Table 6.9. Measurements of Variables for Research Priority 5

Variable	How Measured
Utilization of school (similar to density)	• Density operationalized as number of students per square feet (Freedman et al., 1971, cited in Weinstein, 1979); ratio of number of people in class to number of available seats (Schettino & Borden, 1976 cited in Weinstein, 1979) • Crowding is considered the "perceived judgment of excessive density" (Stokols, 1972, cited in Weinstein, 1979)
Academic achievement/growth	• Standardized tests used in the literature: Test of Academic Proficiency for grade 11, students' Iowa Test of Basic Skills, Comprehensive Tests of Basic Skills, Wisconsin Student Assessment System, Texas Assessment of Academic Skills, Stanford Achievement Test - 9, Arkansas Benchmark Test, Pupil Evaluation Program test, Minimum Basic Skill test, High School Proficiency Test • Performance tests in literature included: Embedded phoneme test (Fowler 1990), Woodcock Reading Mastery Test (Woodcock 1987)
Student attendance	• Measured as total days of attendance divided by total possible days of attendance (Lewis, 2001); Student attendance rate obtained from the Texas Education Agency's Division of Communications and Public Information (O'Neill & Oates, 2000); Attendance rates as reported by the principal (Lindsay, 1982 cited in Fowler, 1995)

Research Priority 6: Effects of Adaptable Seating

Hypothesis: Students in classrooms with seating that can be adapted to suit a variety of pedagogical teaching strategies will experience reduced off-task behavior and increased academic achievement when compared with students in more static classrooms.

This research priority is somewhat similar to priority 1 (team work stations) because both address physical accommodations designed to support alternative pedagogical techniques, likely those that are more learner-centered than teacher-centered. Adaptability of the school building improves the likelihood that facilities are appropriate, functional spaces in which learning occurs. Delphi panel members who participated in this research suggested that if seating can be easily manipulated in order to support a variety of pedagogical teaching strategies that students will be less bored and less frustrated (boredom and frustration are potential mediators) than those in learning environments without manipulable seating, resulting in reduced off-task behavior and greater academic achievement. Whether or not teachers actually use a variety of pedagogical strategies will likely moderate the effects. Table 6.10 lists measures for variables that were reviewed.

Table 6.10. Measurements of Variables for Research Priority 6

Variable	How Measured
Adaptability of seating	• None identified
Academic achievement/growth	• Standardized tests used in the literature: Test of Academic Proficiency for grade 11, students' Iowa Test of Basic Skills, Comprehensive Tests of Basic Skills, Wisconsin Student Assessment System, Texas Assessment of Academic Skills, Stanford Achievement Test - 9, Arkansas Benchmark Test, Pupil Evaluation Program test, Minimum Basic Skill test, High School Proficiency Test • Performance tests in literature included: Embedded phoneme test (Fowler 1990), Woodcock Reading Mastery Test (Woodcock 1987)
Off-task behavior	• Measured as students were videotaped and their behaviors identified by 3 trained educators (Grangaard, 1995);

Programmatic: Resources

Research Priority 7: Effects of School Integration Into Local Community

Hypothesis: When a school is well-integrated into the community, students will feel more valued by the school and will experience greater social development, improved job opportunities, reduced transience, and greater satisfaction. Parents will also be more satisfied when compared with parents of students in schools that are not well-integrated into the community.

The community is seen by educators as a very important resource. Involvement from parents and local businesses is usually welcomed and may provide students and school employees with valuable assistance, information sharing, needed equipment, or other types of support. School involvement with the local community (and vice versa) may produce many benefits – financial, social, and academic. Community schools are partnerships between schools and the community where schools are open practically all day, every day. The Delphi panel members perceive that if the school is well-integrated into the local community, students will feel more valued by the school and experience greater social development, improved job opportunities, reduced transience to other schools, and greater satisfaction. Parents will also likely be more satisfied with their child's school when the school is well-integrated. These relationships need to be studied in the near-term to determine what strategies can be employed to ensure that schools are well connected to their surrounding community and whether or not desired outcomes are produced when they are. Table 6.11 lists measures of variables that have been studied in the reviewed literature, with "student satisfaction" as the only one previously measured.

Table 6.11. Measurements of Variables for Research Priority 9

Variable	How Measured
School integration into the community	• None identified
Student satisfaction	• Student satisfaction was measured by Lindsay (1982), cited in Fowler (1995), by asking students how satisfied they were with required courses; Student and teacher satisfaction measured by Ahrentzen and Evans (1984) using a question on a questionnaire rating satisfaction with the classroom environment (5 point scale) • Other types of satisfaction may be affected, such as satisfaction with post-secondary preparation
Students feelings about how they are valued by the school	• None identified
Student social development	• None identified
Student transience	• None identified
Willingness of local business to hire students	• None identified
Parent satisfaction	• None identified

Ambient: Comfort, Health & Safety

Research Priority 8: Effects of Daylit Classrooms

Hypothesis: The provision of predominantly daylit classrooms is correlated with higher student academic achievement, lower absentee rates, fewer student suspensions, and improved teacher satisfaction when compared with predominantly artificially lit classrooms.

The Heschong et al. (2002) study provided convincing evidence of the effects of daylighting on improved academic performance, and the Delphi panel expressed that it is important to better understand the effects of daylighting, including its effect on non-achievement-related variables. Although daylighting was correlated with academic achievement, Heschong et al. (2002) did not provide evidence of causality. They proposed several possible mechanisms such as improved vision due to factors such as higher illumination levels or better color rendering that have not yet been tested;

improved student and/or teacher morale or performance from mental stimulation; a calming effect of daylight; and greater mental awareness from responses to daylight. There is little or no research evaluating these types of mediating variables, so there are still many questions for researchers to address. Table 6.12 lists measures for variables included in the daylighting hypothesis developed by the panel.

Table 6.12. Measurements of Variables for Research Priority 8

Variable	How Measured
Daylit classrooms	• Measured by Heschong et al. (2002) as: Window code (0=none; 5=excellent, large windows on two sides**); S**kylight code (code assigned according to top-lighting type: diffusing lens, allows patches of sunlight to enter, manually controlled or electric dimming louver, no controls, etc.)**;** Daylight code (5=excellent, could operate without electric lights most of the year; 2=poor, small areas of some daylight; rarely, if ever, able to operate without all of electric lights on)
Academic achievement/growth	• Standardized tests used in the literature: Test of Academic Proficiency for grade 11, students' Iowa Test of Basic Skills, Comprehensive Tests of Basic Skills, Wisconsin Student Assessment System, Texas Assessment of Academic Skills, Stanford Achievement Test - 9, Arkansas Benchmark Test, Pupil Evaluation Program test, Minimum Basic Skill test, High School Proficiency Test • Performance tests in literature included: Embedded phoneme test (Fowler 1990), Woodcock Reading Mastery Test (Woodcock 1987)
Student attendance	• Measured as total days of attendance divided by total possible days of attendance (Lewis, 2001); Student attendance rate obtained from the Texas Education Agency's Division of Communications and Public Information (O'Neill & Oates, 2000); Attendance rates as reported by the principal (Lindsay, 1982 cited in Fowler, 1995)
Student suspensions	• Measured as number of out of school suspensions/100 students and number of in-school suspensions/100 students. Obtained from the Texas Education Agency's Division of Communications and Public Information (O'Neill & Oates, 2000); Number of suspensions divided by total number of students
Teacher satisfaction	• None identified

Ambient: Aesthetics & Appearance

Research Priority 9: Effects of Level of Maintenance and Building Quality

Hypothesis: Students in buildings that are well maintained and of good quality will perform higher on measures of achievement, create fewer disciplinary problems, and have higher attendance rates than students in poorly maintained buildings and of poor quality.

Our nation's schools are suffering from deferred maintenance. The problem exists because schools are aging, there are more students enrolled than ever before, and spending on maintenance is lower than it has been in the past. Schools simply are not spending enough to correct the problems (Lawrence, 2003). There have been several studies that have evaluated relationships between student achievement and building condition (Edwards, 1991; Cash, 1993; Earthman et al., 1995; Lewis 2001; O'Neil and Oates 2000), each showing a correlation between schools in better conditions and improved student test scores. Perhaps one of the greatest research needs is to determine which facility rating method is the most reliable instrument (or develop a better one) and to encourage researchers to consistently utilize the same tool in future research. Table 6.13 lists measures of the variables included in the hypothesis above.

Table 6.13. Measurements of Variables for Research Priority 9

Variable	How Measured
Level of maintenance/building quality	• Measured using various building assessments: the Commonwealth Assessment of Physical Environment (researcher developed)(Cash, 1993); the D.C. Committee on Public Education Report (Edwards, 1991); Construction Control Corporation facility scores (Lewis, 2001)
Academic achievement/growth	• Standardized tests used in the literature: Test of Academic Proficiency for grade 11, students' Iowa Test of Basic Skills, Comprehensive Tests of Basic Skills, Wisconsin Student Assessment System, Texas Assessment of Academic Skills, Stanford Achievement Test - 9, Arkansas Benchmark Test, Pupil Evaluation Program test, Minimum Basic Skill test, High School Proficiency Test • Performance tests in literature included: Embedded phoneme test (Fowler 1990), Woodcock Reading Mastery Test (Woodcock 1987)
Student attendance	• Measured as total days of attendance divided by total possible days of attendance (Lewis, 2001); Student attendance rate obtained from the Texas Education Agency's Division of Communications and Public Information (O'Neill & Oates, 2000); Attendance rates as reported by the principal (Lindsay, 1982 cited in Fowler, 1995)
Student behavior/discipline	• Measured as number of expulsions, suspensions, and incidences of violence/ substance abuse compared to the number of total students (Cash, 1993); off-task behavior measured as students were videotaped and their behaviors identified by 3 trained educators (Grangaard, 1995); Cameras were mounted in each classroom out of the view of students. Cameras made a photographs sequence of time-lapsed pictures (Ott, 1976); number of out of school suspensions/100 students and number of in-school suspensions/100 students. Obtained from the Texas Education Agency's Division of Communications and Public Information (O'Neill & Oates, 2000); total number of reported disciplinary incidents per pupil for the year (Earthman, Cash, & Van Berkum, 1995); student class cutting and student tardiness (Wenglinsky, 1997)

Discussion

The utility of these research priorities may be expanded if they can be used to create a model of the important relationships between physical variables in a school and desired outcomes. Based on their review of the literature, Moore and Lackney (1994, p. 15) proposed a mediational-interactional model of environmental factors affecting educational outcomes. In this model, independent factors were categorized under the headings of “physical environment” or “social environment”. Mediating factors were “behavioral”, “attitudinal”, or “physiological”. The educational outcomes were categorized as “achievement outcomes” or “pro-social outcomes”. It was not possible to fit the research priorities developed in this dissertation into their model exactly. A model for the research priorities has been proposed in Figure 6.1, based on the recommended hypotheses proposed by the Delphi panel. This model has been strongly influenced by the Moore and Lackney (1994) model.

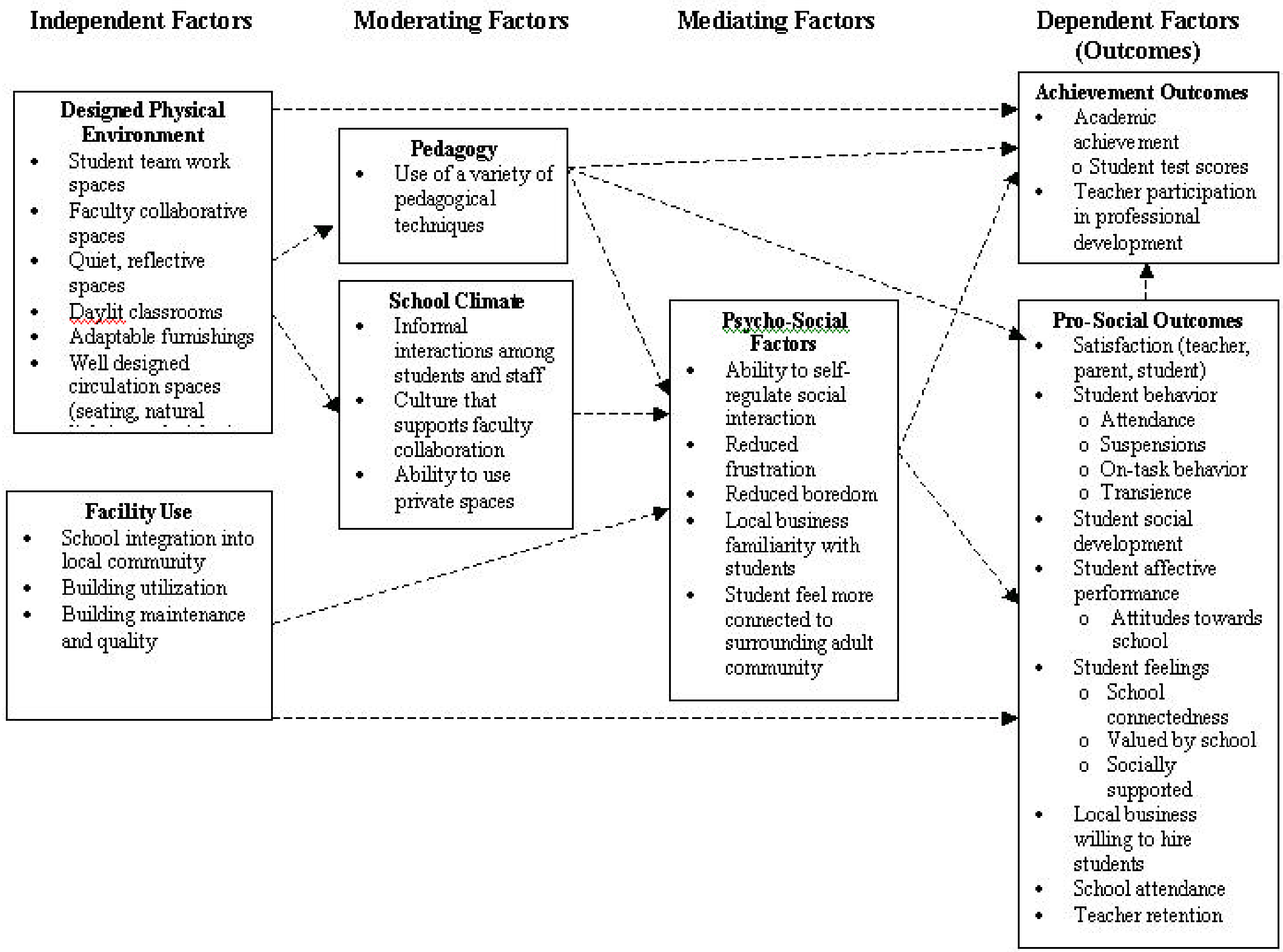


Figure 6.1. Mediational-Interactional Model of Research Priorities

The proposed model includes the moderator “school climate”. For example, even if a school building provides faculty collaborative spaces, there is likely to be little impact on educational outcomes if the school climate does not encourage teachers (and provide time for them) to use those spaces. Therefore, school climate moderates (i.e., interacts with the independent variable “provision of faculty collaborative spaces”) to influence whether or not (or to what degree) the hypothesized outcomes will occur.

This chapter has shown that although there are many factors affecting whether or not SFE research helps practitioners build and operate better schools, one reason for the apparent lack of research utilization is a gap in knowledge regarding specific, plausible relationships between facilities and outcomes that educators perceive to be important. The proposed research priorities, if adopted by researchers in the field, will help fill that void to create relevant knowledge. Chapter 7 provides specific recommendations regarding how this work may be extended to positively impact future research and to ensure that schools will, in the future, provide optimal environments for teaching and learning.

CHAPTER 7

SUMMARY, NEXT STEPS, AND MERIT

Purpose

Chapter 7 provides a summary of the conclusions derived from the study, presents recommended next steps for follow on work, and describes the merit and impact of this research.

Summary

As previously stated, a large number of school facilities in the United States are old, out-of-date, poorly maintained, and lack specific design elements that are likely to enhance teaching, learning, behavior, and other desirable outcomes. Although there have been studies over the past thirty or forty years to examine these types of relationships, this study has shown that there is a remaining gap in knowledge concerning important links between the physical school environment and educational outcomes. The methodologies used in the past were sometimes not scientifically rigorous, and there have been few replication studies conducted. Even though it is known that the physical environment does affect, to some degree, outcomes such as behavior, attitudes, and achievement, researchers are not yet able to accurately predict the outcomes, nor do they understand the causal mechanisms linking the environment and those outcomes in most cases. Currently, researchers from wide variety of fields (e.g., architecture, education, building technology) conduct research within their own interest areas. Although there are organizations, such as the Council of Educational Facility Planners International (CEFPI) and the National Clearinghouse for Educational Facilities that provide research information regarding school facilities, there is no specific set of recommended research priorities guiding current and future research to ensure that it is relevant to practitioners.

The methodologies applied in this study were successfully used to solicit knowledge and perceptions from various groups of key stakeholders to gain some level of consensus regarding high priority research topics. The literature analysis provided important physical and outcome variables to seed the brainstorming lists used in following phases of the research. Concept mapping allowed a group of seventeen educators to identify, sort, rate, and categorize a large number of outcome variables (i.e., measures of student, school or district success) into clusters of those variables to guide future discussions. The Delphi method involved a group of seventeen SFE researchers to identify a list of physical variables that are plausibly linked to educational outcomes, rate their importance, develop hypotheses that should be tested, and to select the most important hypotheses that should become research priorities for the field. The overall approach used may successfully be applied in replication studies of this sort, or used in other fields of environment-behavior research.

In Phase I, a review of SFE literature (with a primary emphasis on ambient conditions) showed that although previous research has investigated correlations between physical school variables and educational outcomes, little is known about causal mechanisms – only one study reviewed tested the role of mediating variables. There is a great deal of variety among the methodologies utilized, and sample sizes varied from as few as eight students to tens of thousands. The majority of previous studies focused on relationships between physical conditions and academic achievement, typically measured using standardized test scores. Attitudes and behavior were other outcomes more commonly studied. Prior to this study, it was unclear whether or not previous research focused on educational outcomes that are the most important to those in education. This was addressed in Phase II.

A concept mapping methodology was utilized in Phase II to solicit feedback from a group of seventeen experienced educators. The educators were asked to brainstorm a list of measures of student, school, or school district success, beginning with a list of items identified in the literature analysis in Phase I. Then, they sorted their final list of more than 100 items into categories that made sense to them, and they rated each item regarding how important it is to monitor or otherwise track. The result was a concept map of fifteen clusters that included these items. The educators rated the "academic achievement" cluster as the most important type of variable to track, but other clusters nvolvement," "school factors," "community involvement," and "collaboration" fell close behind. An evaluation of their ratings for individual items revealed that they rated thirty-five of them as important (using a 3.2 rating out of 4 as a cut-off). The top rated items were: reading skills, attendance, staff development, mathematics achievement, parental involvement, and academic growth. Although SFE researchers have examined a host of outcome variables in the past, there seems to be quite a large number of variables that are important to educators that have received very little attention in previous research. Some of these include: parental involvement (as an outcome rather than an independent variable); teacher/administrator retention; teacher/administrator participation in professional development; teacher mentoring; community business satisfaction with student employees and graduates; student transience rate; general and special education cohesiveness (i.e., how well the special and regular education programs work together); multiple retentions; and community support.

Once outcomes that are important to educators were identified in Phase II, SFE researchers were asked to identify physical variables plausibly linked to those outcomes and to develop hypotheses to guide future research. These tasks were accomplished in Phase III using a Delphi technique. Through a series of four questionnaires, a group of seventeen experienced researchers were asked to brainstorm a list of physical variables plausibly related to educational outcomes, rate the importance of those items, develop hypotheses that included top-rated physical variables and top-rated outcome variables (i.e., measures of success rated by educators), and then select from their list of hypotheses those that most need to be studied in the near-term. The Delphi panel members generated a list of 114 physical variables and rated thirty-eight of them as important (3.2 or higher out of 4). Like the educators, the researchers on the Delphi panel also identified some high priority variables that have received very little attention in the SFE domain to date. These include: child's perceived safety; telephones in classrooms; indoor air quality (a recognized research need, but very few studies have been conducted); views to the outside (non-school studies are available); faculty collaborative spaces; conference spaces; accessible phone, copier, fax (for students, not just teachers); fluidity of seating and work surfaces to meet changing needs; informal learning spaces; adult-student spatial integration; student display spaces and studios; and acoustic privacy from other groups (when students work in teams). More than thirty percent of the important physical variables were related to ambient environmental conditions (e.g., lighting, thermal conditions, acoustics) and several others were related to facility maintenance (e.g., building condition). An unanticipated outcome was that this list of important physical variables included a much broader set of variables than those that have been previously studied. Several of the physical variables are design elements intended to promote collaboration and social interaction, reflecting a current trend in school design (as well as office design) to create spaces designed for teams to work together or meet informally. There is currently little information about whether or not such spaces actually improve social development, student affective performance, behavior, or academic achievement. Several of these types of physical variables became part of the priority hypotheses developed by the Delphi panel.

The high priority hypotheses developed by the Delphi panel reflect the fact that SFE researchers are no longer interested primarily in ambient conditions, as only one of them addressed this type of variable (daylighting). Other physical variables included in these hypotheses are team work areas for students, faculty collaborative spaces, utilization of the school facility, well designed circulation spaces, private spaces, building maintenance, adaptable seating, and school integration into the community. These hypotheses, although they address some physical conditions already studied to some extent in the past (daylighting, building maintenance, and utilization of the school facility), largely take future research in a new direction focused on adaptability, collaboration and social interaction. Also, several of these hypotheses recommended a need to investigate the effects of these physical conditions on a variety of outcomes (not limited to achievement and behavior) and include probable mediators and moderators.

Next Steps

Extending This Work

The very next step is for researchers to begin tackling the questions presented in the set of research priorities defined in Chapter 6. A very interesting follow-on to this study would involve using the data regarding important physical variables (developed by researchers) and ask the educators to rate how important they believe each one is with respect to the measures of success they identified as important. Past studies (Lackney, 1996; Schneider, 2002b) have evaluated educator perceptions about what physical factors affect outcomes related to teaching and learning. There does seem to be a disconnect between the research priorities developed by the Delphi panel and educators' perceived problems with school buildings, such as inadequate science labs and inappropriate room sizes, indoor air quality, and electrical outlets (Schneider 2002b).

A follow-on study to replicate the concept mapping exercise with additional groups of educators would be useful for confirming that the measures of success identified as important to one this study group are also important to the broader groups of educators that they represent. Similarly, replication of the Delphi process with another group of SFE researchers, including several outside of the United States, could validate whether the top rated research priorities apply to a larger population. There is another approach that could also be explored. First, these research priorities, although based on responses from both educators and SFE researchers, should become the starting point for discussion and revision by researchers to increase buy-in. A formal research agenda published by the CEFPI would likely have quite an impact on guiding future research. A series of workshops is envisioned. Beginning with researchers (perhaps in conjunction with a future CEFPI conference), a working group could come to consensus about the top-priority research questions and suggest methods for addressing them. Further, a plan of action for identifying operationalized definitions for physical and outcome variables is an important next step that could perhaps be tackled in a second workshop. Without some agreement on ways to operationalize the variables, researchers will continue to use a myriad of measures that cannot easily be compared using meta-analysis.

Several of the high priority hypotheses identified in this study include a complex set of relationships between physical variables and educational outcomes, moving SFE research away from a traditional univariate approach, one that links specific physical variables with specific educational outcomes, towards the application of a more ecological approach that considers many variables at the same time and their effects on one another. Further study of these hypotheses will require not only operationalization of the variables, but new or modified methods to study them. Table 5.6 provides a structure for each of the priority hypotheses in terms of distinguishing whether the variables are independent or dependent variables, moderators, or mediators. The greatest challenge may lie in developing research methods that adequately investigate the relationships among these variables. Although these hypotheses will move the SFE field into new directions by focusing attention on complex, multi-variate relationships, they will be difficult to study. Yet, it is important to do so. For example, a study that examined whether or not the provision of student team work spaces was associated with students' sense of being socially connected, as well as student, teacher, and parental satisfaction could be misleading without examining whether or not there was actually an increased use of a variety of pedagogical techniques (a mediator) in schools that provide these work spaces. An important next step is for researchers to begin developing appropriate methods for addressing these complex types of relationships. It will be important for researchers to examine non-traditional (i.e. non-correlational) methods, such as case studies to evaluate effective schools and identify similar patterns among them.

In addition to the research priorities listed in Chapter 6, there are other high priority physical and outcome variables that were identified by participants in this study that have not been covered in previous literature. A second tier of research priorities could be based on these variables listed in Tables 6.1 and 6.2.

Finally, another useful extension of this research would be to apply this same methodology in another environment-behavior field, such as effects of "green" building on occupants, to identify high priority relationships among variables and to develop a set of research priorities. If shown to be effective, this methodology will become a valuable contribution to the environment-behavior field and possibly others.

If the research priorities identified in this study are further refined and pursued, progress will be in understanding the relationships between schools facilities and educational outcomes. Knowledge that is relevant to researchers and practitioners alike may bring about a state of data availability that will provide school designers, decision makers, building managers, and other stakeholders with important tools to help them ensure that schools provide the best environments for learning.

Moving Beyond Traditional SFE Research

In addition to pursuing a formalized research agenda and investigating important relationships between schools and their effects on occupants, there are two other broad areas of research that may encourage decision makers to utilize research findings to improve school facilities (if given appropriate funding to do so). These include: 1) improving communications by researchers with designers and building managers; and 2) identifying methods for utilizing post-occupancy evaluation (POE) data collected by practitioners in research. The following subsections describe these research areas in more detail.

Communicating research findings to designers and building managers

Researchers often write (or assist with the writing of) design guides and other similar documents to translate research findings into tangible strategies for designers to incorporate into their designs to improve schools. For example, Moore and Lackney (1994) conducted a review of the empirical literature regarding school facility effects on performance issues, as well as architectural literature regarding trends in school design to derive twenty-seven design patterns that are important to twenty-first century schools. These patterns are categorized into four clusters – planning principles (e.g., safe location, contextual compatibility), building organizing principles (e.g., compact building form, design diversity), the character of individual spaces (e.g., variety of learning spaces, cluster of teacher offices) and critical technical details (e.g., controlled indoor climate, natural/full-spectrum lighting). In addition to describing these design patterns in detail (and the literature to support them), the authors also proposed prototype designs for new schools. What is unclear is the extent to which this monograph and other similar types of documents are actually used by designers to incorporate findings from the research that may help them improve educational facilities. More recently, Lackney (2002) developed a set of thirty-three design principles for schools. An additional next step for extending the work of this dissertation could involve the development of design guidance based on the physical variables that were identified as important by the Delphi panel with respect to educational outcomes.

Bosch and Pearce (2003) conducted a review of nine design guides or similar documents that may be used to educate school stakeholders about high performance school design. They identified a need to critically review the effectiveness of those guides. The guides are often written for a variety of intended users, such as owners, designers, occupants, and building operators, but there appears to be a mismatch between the intended audience and the organizational structure of the guidance documents. Does the organizational structure of the documents affect the ability of different users to comprehend and apply the information contained therein? Are certain types of documents more effective than others and why? We do not yet have answers to these questions that may help us better develop materials for translating research findings into guidance for other stakeholders of the built environment.

Acquiring information from designers and building managers

Another important research direction is to identify mechanisms to help researchers access data collected by designers, building mangers and other researchers. Building assessments and post-occupancy evaluations (POEs) can and should become an important source of data for researchers. Beginning in the year 2000, the School Construction News and Design Share awards program openly encourages (without requiring) POEs of recently occupied school facilities (Lackney, 2001) in order to raise awareness of the importance of POEs in educational facilities. Few POEs, however, are conducted at the diagnostic level, the most comprehensive type of POE that uses many methods for evaluating building performance (Preiser, 1988). These investigations rely on more sophisticated data collection and analysis. An important goal of a diagnostic POE is to provide an understanding of the relationships between variables (physical, environmental and behavioral) so as to predict building performance for a more generalized building type.

One challenge with using POE information is that the data are currently scattered rather than collected in a centralized location and accessible to researchers. There are on-going efforts to improve the POE process. The POE Summit is a series of meetings (begun in November, 2002) to bring together top executives from public building delivery organizations (e.g., General Services Administration, Naval Facilities Engineering Command) to share POE experiences, identify barriers to POE implementation, discuss if and how POE benchmark data may be shared, and to consider whether or not there will be joint efforts to develop technologies and approaches (http://herring.cc.gatech.edu/poeSummit). One of the outcomes anticipated from the Summit is a Memorandum of Understanding that establishes a framework for next steps to take. Another research endeavor at the Georgia Institute of Technology is the development of a comprehensive multi-media courts information database. Although specifically for courthouses, this project demonstrates an effort to centralize data about a specific building type, making it accessible to other stakeholders. A similar centralized database developed specifically for K-12 schools could make a significant step forward to improve the use of POE data to design and operate better schools.

There are at least two important guidance documents that have been developed to aid those who wish to conduct a school POE. Henry Sanoff (2001) developed *School Building Assessment Methods,* a guide for communities that will be involved with school expansion and new construction. A collection of surveys and discussion guides are included to help stakeholders identify "what works and what does not work in K-12 schools" (Sanoff, 2001). The second guide, developed for the CEFPI, is the Guide for School Facility Appraisal (Hawkins & Lilley, 1998). While these documents are appropriate for the purposes for which they were developed, they were not designed to help designers or facility managers to collect the type of data that will be readily applicable in future SFE research.

Another potentially important data source is developed during school building assessments conducted by facility managers or operators. The types of instruments currently used to identify needed repairs, prioritize maintenance items, and report the information to those higher up in the school system vary from one school district to another. In fact, the procedures used sometimes vary from school to school within the same district. There is currently no standardized instrument for collecting information or reporting it. Therefore, the use of a standardized approach, such as provided in the *Facilities Information Management: A Guide for State and Local Education Agencies* (U.S. Department of Education, 2003) must be explored. One challenge with relying on facility managers to provide data needed for SFE research is that they typically do not focus their attention on socio-spatial types of issues (e.g., provision of team work stations or private spaces), such as those that were recommended in the research priorities.

There are many ways in which this dissertation research may be advanced through replicating this work, conducting related studies, refining research priorities in the context of workshops, communicating research findings to other school stakeholders, and acquiring data from designers and facility managers. This study provides an important contribution to the SFE field, and the merit of this work is described in the following section.

Merit and Impact

This study has provided several important contributions to the SFE field of research. Many previously conducted studies in the field are based on an experimental research design and focused on correlations between physical conditions in schools and outcomes such as academic achievement, behavior, and health. Others have used action research and other approaches to solicit information from educators regarding their perceptions about how the physical school environment affects students and teachers. This study, in contrast, utilized a multi-method research design to solicit responses from both educators and researchers to identify relevant physical and outcome variables on which to focus future research, as well as a specific set of research priorities. The combination of a literature analysis, concept mapping exercise, and a Delphi study was successful in meeting the objectives of this research and may prove to be valuable in other fields in which there is a need to better understand the priorities of practitioners to increase the likelihood that future research will be meaningful to their work.

Perhaps the most significant contribution of this study is the set of specific research priorities. Because both educators and researchers were involved in developing them, it is probable that these priorities will be well received by a larger audience educators and researchers alike. With agreement on research priorities among these various stakeholders, as new knowledge is developed through research, practitioners will be more likely to implement the findings (provided that other factors, such as funding availability, are favorable) to design and operate better schools.

In addition to the set of near-term research priorities, this study has also acquired input from educators and researchers to identify lengthier lists of relevant variables that are important for understanding how schools affect educational outcomes (i.e., measures of student, school, or school district success) that matter to educators. Many of the physical and outcome variables that were rated as important by these participants have not been studied in previous SFE literature.

The contributions of this study increase the likelihood that additional, relevant knowledge will be acquired through future research by those who come from a wide variety of disciplines and sub-specialties. As other school stakeholders (including school designers and building managers) become contributors to future research and adopt best practices based on the findings, students and teachers will benefit from higher quality learning environments that promote student achievement, teacher professional development, satisfaction, and other desired outcomes.

APPENDICES

Variable	I,C,D	How Measured	Relationships to Other Variables	Subjects	Source
Interior spacious-ness	I	Ceiling height, square footage, square footage per person, cubic footage per person and percentage of furniture occupying floor space. In the end, only ceiling height and sf per person were used.	For teachers, greater ceiling height related to less visual and kinetic distraction and greater satisfaction with classroom. SF per person not related to visual distraction but negatively related to kinetic distraction and positively related to satisfaction with the classroom. Larger room spaciousness strongly related to reduced visual and kinetic distraction. For students, greater ceiling height related to less visual distraction from student movement and greater distraction from physical contacts.	13 fourth, fifth and sixth grade teachers and 65 randomly selected students 9-13 yrs (upper middle class population) from 5 elementary schools	Ahrentzen, S. and G. W. Evans (1984) *Environment & Behavior*

Variable	I,C,D	How Measured	Relationships to Other Variables	Subjects	Source
Perimeter structures	I	Perimeter structures: % of perimeter of classroom with permanent (or structural) walls, nonpermanent walls of full height and variable height, open entrance space (not regular doors). For each classroom, these 4 percentages total 100%. In the end, only % of structural walls and % of open perimeter space were used.	For teachers, Large amt structural walls related to less teacher distraction, more satisfaction and less restriction of activities. Open perimeter space associated with less kinetic distraction and greater classroom satisfaction, but unrelated to restricting activities. Greater % of structural walls was negatively related to a number of aural and visual distraction measures (degree of open perimeter space was not related to visual distraction, but it was negatively related to perceived crowding and positively related to perceived noise. Open perimeter space was also positively related to teacher satisfaction with the classroom. Not related with teacher restriction of activities. For students, % structural walls only related to aural distraction to loud sounds outside the classroom. It was related to student satisfaction with the classroom and to satisfaction with reading in the classroom. Open perimeter space not related to any distractions nor satisfaction with tasks in the classroom, but it was negatively related to student satisfaction with classroom		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Privacy amenities	I	Desk type (shared or separate) and whether classroom had a secluded study space (physically distinct areas smaller in scale and size than the regular classroom, intended to accommodate only a few students.	Those with privacy amenities (secluded study space and individual desks) report lower levels of privacy than those without (maybe due to limited access to them)		
Distraction	D	Self report questionnaire using a 5-point scale. Aural, visual and kinetic distraction measures were included (reflecting the type of stimulation)	For teachers: Large amount of structural walls related to less teacher distraction. Less kinetic distraction associated with open perimeter space. Larger room spaciousness is related to reduced visual and kinetic distraction. For students: % structural walls not associated with visual, kinetic or aural distraction. % open perimeter not associated with distraction.		
Satisfaction with the classroom env.	D	A question on the questionnaire rating satisfaction with the classroom env. (5 point scale)	Satisfaction positively related to degree of open perimeter space, greater ceiling height and more sf per person for teachers. Student ratings of satisfaction are unrelated to interior spaciousness and negatively assoc. with % open perimeter spaces. Greater structural walls positively related to student satisfaction but unrelated to teacher satisfaction		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Teacher restriction of activities to avoid disturbing others	D	Self report- additional questions on questionnaire (if restriction, and what activities). Teachers were also asked whether they had established rules to deal with the physical design of the classroom regarding noise, traffic or student movement, and places students were not allowed to use freely.	Those who reported restricting activities were in classrooms with less structural walls. Not related to open perimeter spaces		
Perceived privacy	D	Students asked to what extent they were able to be alone when they wanted and where they liked to be (in the classroom) when they needed to concentrate.	In classrooms with privacy amenities, students actually reported lower levels of privacy than those in classrooms without. Perhaps due to limited access to them.		
Age of the school	I	Year school was built	Higher achievement in math, reading, listening and language, fewer health problems, fewer discipline problems and higher attendance in new school	280 fourth and sixth grade students In 2 schools (some in a new and old school), not randomly selected. Students were not matched between schools with others of similar achievement	Bowers, J. H. and C. W. Burkett (1987) 64th CEFPI conferenc e
Attendance	D	Attendance records	Higher attendance in new schools		
Health	D	Number of major health problems (not specified how data were obtained) as reported by the school nurse. These included pneumonia, strep infections, eye infections, chicken pox, ear infections, & a heart condition. No exact numbers for flu reported.	Fewer health problems in new schools		
Discipline	D	Number of corporal punishments (paddling), suspensions	Fewer discipline problems in new schools		
achievement	D	Reading, listening, language and arithmetic (specific tests not specified)	Higher achievement in math, reading, listening and language in new schools		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Building condition	I	Commonwealth Assessment of Physical Environment (researcher developed). These assessments were conducted by school personnel in the divisions of the schools. The rating is either substandard, standard or above standard. It includes factors related to climate control, acoustics, illumination, student density, science equipment adequacy, building age and cosmetic condition.	See below	Rural high schools in VA, 47 schools total	Cash, C. S. (1993)
Student Achievement	D	Scaled scores of the Test of Academic Proficiency for grade 11 in: reading comprehension, mathematics, written expression, sources of information, basic composite, social studies, science, complete composite.	Higher achievement found in buildings with higher quality ratings. When divided, higher achievement related to higher cosmetic conditions ratings, while achievement scores were nearly identical for lower and upper scoring schools on structural ratings. Science achievement was higher in buildings with better quality science facilities. Higher achievement in schools with at least some air conditioning in instructional spaces, schools with less graffiti, better locker conditions, better science lab equip., classroom furniture in better condition, pastel painted walls instead of white in instructional areas, and schools with less noisy external environments.		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Student Behavior	D	Number of expulsions, suspensions, and incidences of violence/ substance abuse compared to the number of total students. Includes 1) ratio of # of suspensions (in and out-of-school) to # students enrolled in high school grades; 2) ratio # expulsion to # students enrolled; and 3) ratio # incidents of violence and substance abuse (as reported to VA Dept of Ed.) to # students enrolled. Each score is a dependent variable.	Better conditions associated with higher incidents per student ratios of violence/substance abuse, suspension and expulsions		
Socioeconomic Status	C	Ratio of # students not on free and reduced lunch to # students enrolled in the high school. Intended to control achievement and behavior variance related to SES.	There was a very low correlation (using Pearson's correlation coefficient) found between building condition and the Local Composite Index (local available $$). Also a low correlation between SES and building condition.		
Air conditioning	I	Presence or absence: obtained by questionnaire completed by the principals of GA standard schools containing 8^{th} grade.	Higher vocabulary scores in air-conditioned buildings. No significant difference in the composite, reading, language, work-study section and mathematics sections.	8th grade students in 191 public, standard GA schools (per requirements established in the "Standards for Public Schools in GA, 1975)	Chan, T. C. (1980)
Carpet	I	Presence or absence: obtained by questionnaire completed by the principals of GA standard schools containing 8^{th} grade.	No significant relationship with achievement		
Fluorescent lighting	I	Presence or absence: obtained by questionnaire completed by the principals of GA standard schools containing 8^{th} grade.	No significant relationship with achievement		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Interior pastel coloring	I	Presence or absence: obtained by questionnaire completed by the principals of GA standard schools containing 8^{th} grade.	No significant relationship with achievement		
Student achievement	D	Results for 8th grade students' Iowa Test of Basic Skills: vocabulary, composite, reading, language, work-study, mathematics sections	Higher vocabulary scores in air-conditioned buildings.		
Socioeconomic status	C	% of paid pupil participation in school lunch program in the 8^{th} grade			
Building age	I	Old school was defined as "dilapidated…with no air conditioning, no fluorescent lighting, no carpeting and no pastel wall coloring.." New school was defined as modern with AC, fluorescent lighting, carpeting and pastel wall-coloring. Pastel defined as lighter shades of blue, yellow, orange, red and green - excluding black, gray and dark shades of brown, green, blue and red.	Students in the new school had more positive attitudes (significantly) about their school building	Control group= 119 students (grades 2,3,4) in an old school building (1936) Experimental group = 96 students (grades 2,3,4) in an old school building (1923) who were moved to a new school (1980)	Chan (1982)
Students' sex	I	Male or female	Females scored higher on pre- and post-test than males in the control group on the School Building Attitude Inventory		
Students' race	I	White or non-white	No effect on pupil attitudes toward their school building		
Socioeconomic status	I	Free and reduced price lunch participation or paid lunch participation	No effect on pupil attitudes toward their school building		
Student attitudes toward their school building	D	Pre-test and post-test scores on the "Our School Building Attitude Inventory" devised by Dr. Carroll McGuffy, U. GA.	Students in the new school had more positive attitudes about their school building		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Social climate in the classroom	I	A modified version of Moos and Trickett's (1974) instrument for studying classroom social climate. The final instrument included 36 items – 1 for each of the 9 dimensions of social climate: involvement, affiliation, teacher support, task orientation, competition, order and organization, rule clarity, teacher control, and innovation.	See below	21,622 students from 678 classes of mainly sixth-grade (some 5th) students in 190 sampled primary schools in Hong Kong	Cheng, Y.C. (1994) *J. of Experimental Education*
Perceived quality of classroom's physical envir.	I	A researcher-developed instrument with 11 items to assess the quality in terms of physical facilities, spacing, neatness, cleanliness and lack of pollution, as perceived by students on a 5-point response scale. Teacher perceptions were also identified and were highly related to student perceptions (demonstration of validity of instrument)	See below		
Class Master's Leader Behavior	I	The Leader Behavior Description Questionnaire (LDBQ) as adapted by Ho (1989). Student responses on 5 point scale	See below		
Use of power (class master's)	I	An instrument developed by Ho (1989) based on the conception of power bases proposed by French and Raven (1968). Includes measures of class master's position power, reward power, coercive power, expert power, and personal power (3 items each). Based on a 5-point scale.	See below		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Individual student affective performance	D	Self-concept (9 items), attitudes toward peers (5 items), attitudes toward school (6 items), attitudes toward teachers (5 items), self-efficacy of learning (10 items), feeling of homework overload (1 item), and intention to drop out (1 item) questionnaire using a 5-point scale. Some items adapted from an Education Research Establishment research project. Others identified in other studies.	Positively related to class master's reward power, but not the other 16 environ. indicators. Attitudes towards peers correlated with perceived physical environment; class master's expert power, person power, consideration and initiating structure; and most of the nine dimension of classroom climate. Negatively correlated with class master's coercive power.		
Noise level	I	Classroom noise (activities) of 4th grade students was tape-recorded. During the experiment, the tape was played so that the mean sound pressure was 70dbA in the noisy envir. and 40 dbA for the quiet envir.	Boys can solve more complex matrix problems than girls in a noisy envir. The study does not suggest a lowering of noise levels, but that noise doesn't affect children in the same way.	156 children from a public school in Central Ohio (72 1st, 36 3rd and 48 5th grade). All of the children were from traditional self-contained classrooms	Christie, D. J. and C. D. Glickman (1980) *Psychology in the Schools*
Intellectual performance	D	Standard Progressive Matrices, 1938 version. 3-4 students were tested simultaneously in the school library with partitions set up. One child and one experimenter were seated behind each partition.	The effects of classroom noise do not vary with age (contrary to previous selective attention research). Older children performed better than younger children on the Standard Progressive Matrix task.		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
School plan (open vs. conventional)	I	*Conventional*: high-set, timber-frame, rectangular bldgs in close proximity to one another in regular alignments. Few trees, paved with asphalt. Self-contained, 25 sf classrooms with windows filling the walls above the 3 ft level on either side of the room and linked by external corridors. Movable desks for 2 students each, chairs, and a teacher's table and chairs *Open*: low-set brick, timber and glass bldgs varying in shape, spaced well apart from one another in landscaped surroundings. Different classroom designs between the 2 schools.	See below	142 intake students from 4 suburban high schools, 2 open and 2 conventional designs	Cotterell (1984) *Environment & Behavior*
Measures of student personality	I	Paragraph Completion Method (Hunt et al., 1977). The sum of scores from 3 topics is used to derive a measure of conceptual level (CL). Responses coded by 2 coders	No interaction between effects between school design and personality. Students with low CL had greater interpersonal anxiety.		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Student anxiety	D	1) A 20-item observation sign-system, the Segment Observation Checklist. Describe classroom activity according to the leadership structure, source of pacing of the activity, type of participation and degree of interdependence of students and 2) the What I Did form. A list of 20 behaviors describing students (e.g., answering questions aloud, helping a classmate). 3) a student kept diary with prompts such as "think of a moment in the day when you were unsure what to do or what to say." Content analysis of the diaries was conducted and events were coded into 3 categories – normlessness and disorientation, schoolwork anxiety, and threat from others.	1 & 2) Teachers in open plan more likely to establish activity structures where students were responsible for their own learning, but to tell students information when needed, rather than elicit knowledge from them through interaction. Also more likely to lecture followed by group work vs lecture followed by seatwork. Transitions between activities occurred more often and lasted longer than conventional. Open plan had higher levels of off-task behavior and peer-related interactions. 3) Students in open plan schools scored lower on normlessness and higher on schoolwork anxiety. They experienced less anxiety about locating classrooms, teachers and classmates and were less uncertain about the working of the school timetable and other school procedures. They were more anxious about performing competently in front of others in class and more apprehensive about getting schoolwork completed correctly.		
Parental involvement	I	Size of the school's PTA budget	Associated with better physical conditions for school buildings and physical conditions associated with higher achievement	Uses 2 data sets – a larger set, and a subset of 52 schools that were surveyed –	Edwards (1991); Also in Meek

Appendix A (cont'd).

Variable	I/C/D	How Measured		Subjects	Source
School condition	I	Poor, fair or excellent. Used a self-assessment rating tool		all in the Washington DC area.	(ed.), *Designing Places for Learning* as Berner (1995)
Type of school building (E, M, H)	C	Elementary, junior high or high school			
School age	C	Number of years			
Racial makeup	C	% black, white and other minorities	"schools in wealthier, more predominantly white areas were likely to have higher average achievement scores"		
Mean income in school's neighborhood	C	Self-explanatory	"schools in wealthier, more predominantly white areas were likely to have higher average achievement scores"		
School enrollment	C		"positive correlation between enrollment and building condition" and negatively correlated with student achievement (higher enrollment, lower scores)		
Student achievement	D	Standardized test scores Comprehensive Tests of Basic Skills	"an improvement in physical condition by one category, say from poor to fair, was associated with a 5.5 point improvement in average academic achievement scores on standardized tests."		
Aircraft noise	I	School within a 65 Leq flight contour (NY). Students also lived within the flight contour. Control school located in quieter environment	Children exposed to chronic aircraft noise have poorer reading skills than those attending elementary school in a quieter neighborhood.	116 first and second graders (53% female), for whom English is their first	Evans and Maxwell (1997) *Environm*

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Language acquisition – sound perception	D	Children exposed to 12 familiar sounds. Sound perception scored as in Brady et al. (1983.	Sound perception is NOT a mediator of the relationship between chronic noise exposure and reading deficits	language, from 2 elementary, predominantly Black schools in New York City	*ent & Behavior*
Language acquisition – speech perception	D	Method that exposes children to high frequency words (Carroll, Davies & Richman 1971). Words were noise-masked. A 0dB signal to noise ratio was achieved (Schroeder 1968). The masked speech stimuli were part of the larger battery of tests in Brady et al. (1983)	Speech perception is a partial mediator of the relationship between chronic noise exposure and reading deficits		
Phoneme Compre-hension	D	Embedded phoneme test (Fowler 1990)	Unrelated to noise levels and also to reading scores		
Reading skills	D	2 subscales of the Woodcock Reading Mastery Test (Woodcock 1987) – word identification and word attack. Raw scores were transformed to standardized scores. Reading ability was the sum of the 2 standardized scores.	Chronic noise exposure is correlated with reading scores (more noise, lower scores)		
Mother's education	C	Variance between the samples was minimized through sample selection (SES) and other factors were similar (e.g., parents' education, ethnicity, English as a 2nd language)			
Lighting (artificial)	I	Cool white fluorescent vs. full-spectrum	See below	five 6-yr old boys and six 6-yr old girls in a public school.	Grangaard (1995) Paper presented at the Association for Childhood
Wall color	I	Semi-gloss white vs. light blue	See below		
Off task behavior	D	Students were videotaped and their behaviors identified by 3 trained educators.	Off-task behavior decreased by 22% in the blue wall/full-spectrum envir., increasing by 1 when the envir. was returned to its original white walls/cool white fluorescent lighting condition		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Blood pressure	D	Recorded once in the morning and once in the afternoon using an automatic digital blood pressure/pulse monitor with a tape print-out.	Group mean blood pressure was reduced by 9% in the blue wall/full-spectrum envir., increasing by 1 when the envir. Was returned to its original white walls/cool white fluorescent lighting condition		Education Internatio nal Study Conferenc e
Daylight	I	1. Window code (0=none; 5=excellent, large windows on two sides 2. skylight code (code assigned according to top-lighting type: diffusing lens, allows patches of sunlight to enter, manually controlled or electric dimming louver, no controls, etc.) 3. Daylight code (5=excellent, could operate without electric lights most of the year; 2=poor, small areas of some daylight; rarely, if ever, able to operate without all of electric lights on)	Capistrano: highest window code associated with 15-23% higher rate of improvement over 1 year period vs. lowest window code. Highest daylighting code associated with 20% faster improvement on math tests and 26% faster on reading in one year. Students in rooms with well-designed skylight (Type A) that diffused light and allowed teacher control improved 19-20% faster than without skylights. Where windows could be opened, students progressed 7-8% faster in 3 out of four cases than with fixed windows. Poorly designed skylights (Type B) were associated with a 21% decrease fro reading tests and no change for math. For Seattle and Fort Collins students, final math and reading scores were 7 to 18% higher for those in rooms with the most daylight vs. those with the least.	21,000 elementary school students (2nd – 5th grade) from 3 school districts (Orange Co., CA; Seattle, WA; and Fort Collins, CO)	Heschong Mahone Group (1999); Heschong et al. (2002) *Journal of the Illuminati ng Engineeri ng Society*
Natural ventilation	I	Operable windows or not	See above		
Air-conditioning	I	Type: new roof top, retrofitted roof top, wall-mounted, none	Not specified		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Grade-level	I	2, 3, 4 or 5	Younger grades make faster progress than older grades (Capistrano). Most powerful predictor of progress from Spring to Fall.		
Gifted and talented	C	Participation in GATE programs	(Capistrano) Negatively correlated – meaning that those who participated in GATE programs made less progress during the year than non-GATE (possibly because they already score high from the beginning)		
Bi-lingual	C	Participation in special bi-lingual programs			
Unverified absences	I		(Capistrano) Slightly negatively correlated with improvement in math.		
School size	I	Enrollment	Small, negative correlation with improvement		
School site	I		(Capistrano) "Approximately 1/3 to ½of the schools showed up in the models as having a significant influence on how much a student learned over the course of the school year." Possibly due to any number of factors (e.g., more involved parents, better neighborhood).		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Student achievement - math	D	RIT scale (Capistrano and Fort Collins); normal curve equivalent (Seattle). "We used two types of standardized student tests in our analysis. Seattle provided us with the Iowa Test of Basic Skills (ITBS), Form M, a national test. The raw test scores were formatted using a Natural Curve Equivalent (NCE) scale derived from national norms, which identifies equal increments in response, such that results at different ends of the scale can be correctly compared on an arithmetic scale. Thus, with an NCE scale, an improvement of 5 points has the same meaning whether it's at the high or low end of the scale. This allowed us to make meaningful judgments about how much of an effect a variable might have across the spectrum of possible scores. Capistrano and Fort Collins provided us with "level tests" developed by the Northwest Evaluation Association (NWEA), specifically tailored to the districts' curricula. Since these tests do not have nationalized norms, they use the Rausch Unit (RIT) scale to create an equal interval scale that is similar to a NCE, but not calibrated to national norms. The RIT scale is calibrated across all (grade) levels of the tests, so that a growth of ten units is equivalent at any point in the scale or level."			

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Student achievement - Reading	D	RIT scale (Capistrano and Fort Collins); normal curve equivalent (Seattle)			
Student academic performance	D	Workshop participants were asked if they felt that specific environmental quality issues affected this. Also teacher surveys	"it is clear that environmental quality is perceived by the occupants of each school in the study as one of the critical indicators of educational quality along side the more familiar indicators as the school's social climate, student socio-economic background and the quality of the student's home and neighborhood environments." Physical comfort & health; classroom adaptability; safety & security; building functionality, personalization & ownership and privacy perceived as affecting student academic performance.	Parents, teachers, students, administrators, non-instructional staff. 19 involved with the work shops and a larger population involved in teacher surveys. 123 student surveys were received.	Lackney (1996)
Student social development	D	Workshop participants were asked if they felt that specific environmental quality issues affected this. Also teacher surveys	Physical comfort & health; safety & security; personalization & ownership; aesthetics & appearance; classroom adaptability; building functionality; places for social interaction perceived as affecting student social development.		
Teacher instructional performance	D	Workshop participants were asked if they felt that specific environmental quality issues affected this. Also teacher surveys	Physical comfort & health; classroom adaptability; safety & security; building functionality are perceived as affecting teacher instructional performance		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Physical comfort & health (teachers and students top 5 envir. Quality attributes of concern)	I	Perceived by action research working groups as being the highest priority (among 10 attributes of env. quality) across the five schools studied. Student questionnaires regarding likes and dislikes. Teacher concerns: poor air flow and ventilation; noise and distraction problems; cold zones in AC bldgs; poor bathroom ventilation; old carpeting; excessive heat May – September; acoustic problems in bathrooms and corridors; scope of custodial responsibilities; plumbing & drainage failure to prevent flooding	Perceived as affecting student academic performance (thermal comfort, poor air flow circulation and ventilation; noise in open space areas,		
Classroom adaptability (teachers and students)	I	Perceived by action research working groups (teachers, administrators and parent volunteers) as being the highest priority (among 10 attributes of env. quality) across the five schools studied. Student questionnaires regarding likes and dislikes. Teacher concerns: effectiveness & adaptability of open plan vs self-contained classrooms; computer installation; need for storage; size and # of tables; inability to hang displays on concrete block walls; need for electrical outlets; difficulty with inter-class projects; problems w/ cooperative learning in self-contained classrooms	Perceived as affecting student academic performance (open plan causes problems with noise and distractions; availability of electrical outlets and lack of cable runs for computers, inefficient layout, space taken up by computers, tightness of space, requirement to use tables that take up more space than chairs)		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Safety & security (teachers)	I	Perceived by action research working groups as being the highest priority (among 10 attributes of env. quality) across the five schools studied. Student questionnaires regarding likes and dislikes. Teacher concerns: Neighborhood quality; unsafe playgrounds; intruders and securing multiple entry points; poor outdoor lighting; psychological safety on playgrounds; vehicular traffic; compromised visibility and daylight with locked and semi-transparent windows; lack of garbage pick-up around dumpsters; inadequate emergency lighting in stairwells; deterioration and lack of maintenance of city alley behind school; poor grounds upkeep; congested main stair.	Perceived as affecting student academic performance (poor neighborhood quality an psychological safety on school grounds, safety & security problems is perceived to affect ability of students to focus on learning,		
Building functionality (teachers)	I	Perceived by action research working groups as being the highest priority (among 10 attributes of env. quality) across the five schools studied. Teacher concerns: ADA compliance; lack of playground equip and adequate tot lot area (?); congestion in main stair; underutilized library/media center; wayfinding by parents to children's classrooms; unorganized central storage room; crowded admin area; inadequate lobby design; mismatch between community school vision and building	Perceived as affecting student academic performance (ADA compliance, mismatches between bldg functionality and organization a activities)		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
		layout; inadequate teachers' lounge furnishing cafeteria/auditorium divider partition in disrepair; lack of assembly space			
Personalization & ownership	I		Perceived as affecting student academic performance (lack of ownership of school grounds affects student attitudes and behavior that may hinder performance; ability to personalize inside the school provides sense of ownership, responsibility for actions; lack of under table storage makes it difficult to provide personalized spaces for students in the classroom.		
Privacy	I		Perceived as affecting student academic performance		
Aesthetics & appearance (teachers and students)	I	Perceived by action research working groups as being the highest priority (among 10 attributes of env. quality) across the five schools studied. Student questionnaires regarding likes and dislikes. Teacher concerns: Appearance of playground; semi-transparent windows; upkeep of grounds; poor appearance of neighboring property and city alleys; old carpeting			
Places for social interaction (students)	I	Student questionnaires regarding likes and dislikes.			

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Sensory stimulation (students)	I	Student questionnaires regarding likes and dislikes.			
Standard cool-white fluorescent tubes and fixtures with solid plastic diffusers	I		Students were observed "fidgeting to an extreme degree, leaping from their seats, flailing their arms, and paying little attention to their teachers"	1st grade children in 4 different windowless classrooms in Sarasota, FL	Ott (1976)
Full-spectrum fluorescent tubes with lead foil shields around the cathode ends	I		"the first-graders settled down more quickly and paid more attention to their teachers. Less nervousness was evident and overall performance was better."		
Behavior	D	Cameras mounted in each classroom out of the view of students. Cameras made a photographs sequence of time-lapsed pictures	"a dramatic improvement in behavior was demonstrated in hyperactive children [in classrooms with full-spectrum lighting]."		
Achievement	D	Composite percentile reading and mathematics scores on the Iowa Test of Basic Skills	See below	The population included 44 elementary schools (representing 22,679 students) in 13 school districts in GA. The sample selected included the upper 20% (8) and lower 20% (8) schools for composite ITBS scores for 5th grade students, but 2 were	Tanner (2000) *Journal of Educational Administration*

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
				dropped, leaving 14 schools	
Socioeconomic variables	I	Students receiving free lunch; Students receiving remedial instruction; Students receiving special education instruction; Students receiving special assistance instruction	"…none of the socioeconomic variables could be linked to a statistically significant effect on the ITBS scores…"		
Design patterns - pathways, positive outdoor spaces, computers for teachers and overall impression significant (also includes living views and others, not significant)	I	A 39-item instrument with a reliability coefficient of 0.90 (for this sample) and a test-retest reliability of 0.82. A total score 0 to 390 was obtained for each school.	"Seven variables revealed significant correlations with the ITBS scores. All significant correlations were positive." These include: context, outdoor rooms, pathways, outdoor space, technology for students, technology for teachers, and overall impression. "Given the R square of 0.95, we may conclude that the seven design variables account for approximately 95 percent of the variability of the ITBS scores in this sample." The best predictors of achievement include pathways, positive outdoor spaces, computers for teachers and overall impression.		
Facility condition and educational adequacy	I	Construction Control Corporation scores: 4 separate measures – existing condition total, existing condition adjusted, educational adequacy total and educational adequacy adjusted.		139 schools in the Milwaukee Public School District	Lewis (2001) Council of Educational Facility Planners International
Student characteristics	C	Attendance, truancy, suspensions, mobility, free and reduced lunch			

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Student achievement	D	Wisconsin Student Assessment System Mathematics, Science, Language, and Social Studies tests of 4th, 8th and 10th grades of each school in 1996, 1997, 1998. For 1996, percentile rankings of the schools on national norms were used. 1997 and 1998 scores were the % in each school above the proficient level.	Using multiples regression analysis, found that "student achievement was significantly related to facility condition in 11 of the 36 estimates between 1996 and 1998. This is far higher than would be expected by chance." "With the complexity of the learning process and the number of factors that can influence it, it may not be possible to produce a definitive estimate of the effect of facility conditions on student achievement. Overall, the evidence -both previous research and this study – strongly implies such a relationship exists."		
Individual ability	I	Reading test scores (significantly improves the model: adj R square is .805 with and .445 without)	"The most powerful independent variable in all of the equations was the Reading score."		
Racial/ethnic group	C	African American, Asian, Hispanic, White [American Indian and other not included in the regression because the sum of any set of variables cannot be a unity (100%)]			
Attendance	C	Total days of attendance divided by total possible days of attendance			
Truancy	C	# absent for 10 or more consecutive days or 10 or more days during a semester divided by the total number of students enrolled on the third Friday of the school year.			

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Suspension rates	C	Unduplicated count of the # of students suspended from the school (multiples counted as once per school) divided by the total number of students enrolled on the third Friday of the school year.			
Mobility	C	Total students who entered or exited a school after the third Friday divided by the total number of students enrolled on the third Friday of the school year.			
% students eligible for free or reduced-price lunches	C	Total students receiving free or reduced price lunches divided by the total number of students enrolled on the third Friday of the school year.	"This is the student characteristics variable that had the most significant relationships with test data."		
Building condition	I	Facility scores - Produced by the Construction Control Corporation for 1991. Comprised of Existing, Existing Condition Adjusted, Educational Adequacy Total, Educational Adequacy Adjusted. Existing condition is based on direct examinations using an evaluation form developed by CCC that calls for ratings on a 5-point scale (poor, marginal, average, good and excellent). The ratings are multiplied by weighting factors, with scores ranging from 1000 to 5000. Then adjusted based on bldg. age. Educational adequacy scores were given by a team of teachers and curriculum specialists. The form was developed by CCC. Rated on conformity to design standards, adequacy to accommodate current curricula and functional performance.	"In 1996, all three of the facility measures had statistically significant relationships with the Mathematics scores. Two other significant coefficients were also found between facility measures and test scores, one each with science and social studies… In 1997, there were six significant relationships and the coefficients were about of the same magnitude… Only one of these significant 1997 coefficients, however, replicated a relationship found in 1996" [Existing Conditions Total score and Science scores]. "In 1998, none of the relationships between facility measure and test scores were significant."		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Facility evaluation	I	The Total Learning Environment Assessment (TLEA) was developed. 82-item, 4 point Likert scale (1=strongly disagree, 4=strongly disagree). 3 major sections; Facility Age, Educational Adequacy, Environment for Education plus another section to solicit other info concerning the facility. Scores assigned by principals. Based partly on the Guide for School Facility Appraisal (Hawkins & Lilley, 1998) and created for this study.	Significant differences in four measures of student achievement between the top and bottom 25% as rated using the TLEA (total score) - % passing reading, % passing math, % passing all sections, and % passing reading, writing and math. No significant differences in student behavior, student attendance or teacher turnover rate. Re: subsections - Building age had the strongest relationship with achievement. Subsection "academic learning space" was positively related to 3 measures of achievement. Subsection "exterior environment" was positively correlated with % 8th graders passing all sections. At the specific question level, there were 65 significant correlations with measures of student achievement including noise, availability of technology and internet/intranet utilization, size and design of specialized learning areas, the extent to which teachers are permitted to function as professionals, and carpeting.	70 middle schools participated. Number of students not specified.	O'Neil and Oates (2000) CEFPI report
Building age	I	Year built	Significantly related (0.01) to all seven measures of student achievement. Building age is highly correlated with the other 10 independent facility variables in the TLEA		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Educational adequacy	I	47 items on the survey in subsections: Academic Learning Space, Specialized Learning Space, Community/parent space and Support	Not specified.		
Environment for Education	I	35 items in subsections: Exterior Environment, Interior Environment, Visual Reinforcements.	Not specified.		
Student achievement	D	% 8^{th} graders passing reading, math, science, social studies, writing, all sections and reading/writing/math on the Texas Assessment of Academic Skills test. Obtained from the Texas Education Agency's Division of Communications and Public Information	See above.		
Behavior	D	# out of school suspensions/100 students and # in-school suspensions/100 students. Obtained from the Texas Education Agency's Division of Communications and Public Information	Out of school suspensions is correlated with all 7 measures of achievement (more suspensions, reduced achievement)		
Student attendance	D	Student attendance rate. Obtained from the Texas Education Agency's Division of Communications and Public Information	Positively correlated (.01 level) will all 7 measures of student achievement		
Teacher turnover rate	D	3-year average teacher turnover rate. Obtained from the Texas Education Agency's Division of Communications and Public Information	Negatively correlated with "percentage of eight graders passing reading" and "percentage of eighth graders passing all sections. Increased teacher turnover is associated with reduced achievement according to these measures. Higher turnover also associated with more in-school and out-of school suspensions.		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
% economically disadvantaged	C				
Student achievement	D	Stanford Achievement Test9 (total performance on all subtests reported as mean percentile ranks) at grades 5, 7 and 10; 3 years of data; Arkansas Benchmark Test for grades 4 and 8 (% performing at the "proficient" level or higher); 2 years of data.	Consistent with similar studies. "School and district size interact with socioeconomic status in ways that seem to regulate the relationship between size (of school and districts) and achievement. Smaller size facilitates academic performance among schools and districts serving impoverished Arkansas communities, and it does so significantly whether the measure of performance is a norm-referenced or a state-designed criterion-referenced test. Moreover, in Arkansas, unlike some of the other states studied, the benefit of larger schools and districts among affluent communities is comparatively weak and more limited."	Two distinct data sets – district level and school level. Data reported for the state of AK – number of students, schools and districts not specified.	Johnson et al. (2002) Size, Excellence, and Equity: A Report on Arkansas Schools and Districts
Socioeconomic status	I	Proportion of school and district enrollment receiving subsidized meals (also interaction of size and SES at both school and district level was included as an independent variable) {note shortcomings as SES proxy include willingness to apply for free/reduced meals; procedures to secure applications; tendency for secondary students to decline]	"significantly and positively associated with all but one of the 18 outcomes (suspensions), with the other variables entering the equations controlled."		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
School size	I	Proportion of total school enrollment to number of grade levels (enrollment per grade span)	School size negatively associated with 6 outcome measures - % passing Reading test (Minimum Basic Skills Test); Average Mathematics test score, average Writing test multiple chose score, % passing Reading test (High School Proficiency Test); and % of students influenced by school and retained (other outcome measures).		
Student achievement	D	Comprehensive Test of Basic Skills administered to 11th graders in the state in the Spring.	"In 18 categories, scores of students in the above standard school buildings were higher than those of students in substandard buildings. In five of the categories, the scores of students in substandard buildings were higher than those in above standard buildings. This analysis does not provide any discernible pattern among those items where the scores of students in the substandard buildings were higher…Those items were: building age, air conditioning in the classroom, noise, exterior painting and acreage in the site. Age of building, air conditioning in the classroom, and noise are building conditions that are important to student learning, and in the previous analyses, these conditions were positively related to higher scores in above standard buildings."	North Dakota. 199 high schools ranging in size from 65 to 1200 students. A response was received from 120 school principals (60%).	Earthman, Cash and Van Berkum (1995) CEFPI Annual Meeting. Used same methodol ogy as Cash (1993)

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Student behavior	D	Total number of reported disciplinary incidents per pupil for the year	Number of reported incidences was very small throughout the state. "…comparison figures are extremely small and in some cases meaningless. Nevertheless, students in the above standard buildings recorded fewer disciplinary incidents than those in the substandard buildings when comparisons were made on the overall and cosmetic conditions of the building." For structural conditions, above standard schools reported more disciplinary incidents.		
Building condition	I	State Assessment of Facilities in Education – self-evaluation (modified version of the tool used in Cash 1993). The evaluation instrument asked about the presence or absence of 29 items (quality not included) in 3 categories – building condition, cosmetic condition, and structural condition. Information used to identify a school as standard (top 25%), standard (middle 50%) or below standard (bottom 25%)			
Demographics	C	Considered to be similar for all schools since North Dakota has a relatively homogenous (rural) population. Scores were adjusted for SES, but unclear what measure was used for SES.			
Achievement Attitudes Social behavior problems		Attitudes: towards school or particular subjects Social behavior problems: discipline problems, vandalism, drugs/alcohol, etc. Self-concept: academic and general	Some conclusions: "academic achievement in small schools is at least equal – and often superior – to that of large schools. Student attitudes toward school in general	A review of 69 (primary, secondary) documents investigating effects of school and unit	Cotton (1996) School Improvem ent

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Levels of extracurricular participation Interpersonal relations with other students and school staff Attendance Dropout rate Self-concept College-related variables		College-related variables: acceptance, completion, etc.	and toward particular school subjects are more positive in small schools. Student social behavior – as measured by truancy, discipline problems, violence, theft, substance abuse, and gang participation – is more positive in small schools. Levels of extracurricular participation are much higher and more varied I small schools than large ones, and students in small schools derive greater satisfaction from their extracurricular participation. Student attendance is better in small schools than in large ones. A smaller percentage of student[s] drop out of small schools than large ones. Student[s] have a greater send of belonging in small schools than in large ones. Student academic and general self-concepts are higher in small schools than in large ones. Students from small and large high schools do not differ from one another on college-related variables such as entrance examination scores, acceptance rates, attendance, grade point average, and completion. Teacher attitudes toward their work and their administrators are more positive in small schools than in large ones… Poor students and those of racial and ethnic minorities are more adversely affected – academically,	size on student outcomes	Research Series

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
			attitudinally, ad behaviorally – by attending large schools than are other students."		
Teacher's cost index	I	"Taken from Teacher's Cost Index calculated by NCES (1995). Consists of estimates of the market value of teachers when measures of teacher quality and other characteristics are held constant." Estimates at state level used		Studied a nationally representative (number not specified) of 4th and 8th graders using a linear structural modeling program (LISREL 8).	Wenglinsky (1997) Report for the Policy Information Center, Educational Testing Service
Instructional per pupil expenditures	I	Derived from data in the Common Core of Data for 1992. Total expenditures on instruction for each school district divided by the number of students in the school district			
Central office administration per pupil expenditures	I	Derived from CCD data for 1992. Total expenditures on central office administration for each school district divided by the number of students in the district			
School administration per pupil expenditures	I	Derived from CCD data for 1992. Total expenditures on school-level administration for each school district divided by the number of students in the district	School level (principal's office) administration not associated with variations in achievement		
Capital outlays per pupil expenditures	I	Derived from CCD data for 1992. Total capital outlays on school-level administration for each school district divided by the number of students in the district	Not associated with variations in achievement		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Socioeconomic status	I	Derived from data in National Assessment of Educational Progress in Mathematics for 1992. A summated scale for each individual responding to the NAEP about whether or not: family receives newspaper; encyclopedia in home; more than 25 books in home; family subscribes to magazines highest level of education attained for mother and father; % of students receiving free or reduced-price lunches			
Teacher-student ratios	I	Derived from data in National Assessment of Educational Progress in Mathematics for 1992. total number of teachers in school by total number of students in school			
Highest degree	I	Derived from data in National Assessment of Educational Progress in Mathematics for 1992. highest level of education attained by teacher responding to NAEP on behalf of individual student	Teacher education levels not associated with variations in achievement		
School environment	I	Derived from data in National Assessment of Educational Progress in Mathematics for 1992. For each school, degree to which teacher absenteeism, student tardiness, student absenteeism, and class cutting are not a problem and the degree to which there is regard for school property; For each teacher, degree to which they have control over instruction and course content. All items scored from 1-4.			

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Mathematics achievement	D	Taken from NAEP data in mathematics 1992. Five values	For 4^{th} graders: higher expenditures on instruction and school district administration increase teacher-student ratios; these increased ratios raise average math achievement For 8^{th} graders: higher expenditures on instruction and school district administration increase teacher-student ratios; increased ratios reduce problem behaviors and improve the school's social environment; reduced problem behaviors and positive social environment improve average math achievement		
Achievement	D	Pupil Evaluation Program test scores for 3^{rd} and 6^{th} graders from the 82-83 school year until the 96-97 year in the Syracuse city school district (NY)	Math scores were significantly correlated with the % students attending a recently renovated school (stronger for 6^{th} graders) In a closer examination of 3 schools over 11 years (too small a sample to provide statistically significant results), reading scores fluctuated with no apparent trend, while math scores improved after renovations when compared to scores prior to renovations. Large influx of non-English speakers may have contributed to lack of improvement in reading scores.	21 elementary schools. A closer examination of 3 similar schools was also conducted	Ott (1999) Report for Council of Educational Facility Planners
Building renovation	I	Recently renovated or not. Recently refers to a major renovation in the past 10 years. Looked at % of students attending recently renovated schools	See above		

Appendix A (cont’d).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Furniture arrangement	I		“the weight of the evidence suggests that design factors can have a significant influence on students’ general behavior (such as movement patterns, purposefulness, disorderliness, persistence, and involvement) and on their attitudes toward the class and other students. On the other hand there is presently no support for the notion that design has an impact on achievement....”	Review article. This chart shows only studies reviewed re: specific environmental variables. The article also reviews ecological studies of spatial behavior and studies of open space classrooms	Weinstein (1979)
Density and crowding	I		“the evidence is sufficient to suggest a number of undesirable reactions, such as dissatisfaction, nervousness, less social interaction, and increased aggression. The impact of crowding on achievement is not yet clear, but he data indicating decrements in complex task performance warrant serious consideration”		
Noise	I		“there has been little research conducted in schools on the effects of realistic noise on student achievement.” There is a need to conduct more research to better understand the relationships between noise exposure and academic achievement.		
Windowless classrooms	I		“research evidence supports neither the claim that windowless class-rooms will allow increased concen-tration, leading to higher achieve-ment, nor the fear that the absence of windows will have harmful psychological and physical effects”		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Various dependent variables, including student behavior, student attitude,	D				
Indoor air quality	I	Presence of total dusts, formaldehyde and other VOCS (benzene, toluene and xylenes). Also air temp, humidity and ventilation	"symptoms or physical/chemical parameters measured in the field did not identify environmental problems potentially related to SBS following attendance at the libraries of the University of Modena and Reggio Emilia. However, some parameters warrant further study, in particular, total dust concentrations and total VOCs levels in some environments were close to or exceeded proposed guideline values."	Users of libraries in the University of Modena and Reggio Emilia	Righi et al. (2002)
Well-being	D	Anonymous questionnaire filled out by those in reading rooms on the day of environmental monitoring. 130 ques-tionnaires total were collected. Similar to others. Has 4 parts: 1) general info such as sex, age, education and occupation; 2) library attendance (frequency, avg time daily, day of time most often using library); 3) possible discomfort - examines ventilation, humidity, light, heat, cold, noise and bad odor; 4) symptoms related to sick building syndrome such as coughing, nausea, headaches, watery eyes, dry skin and whether onset occurs in library or			

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
		irrespective of using the reading room.			
School connectedness	D	Student survey soliciting responses to 5 statement: 1) I feel close to the people at this school; 2) I feel like I am a part of this school; 3) I am happy to be at this school; 4) The teachers at this school treat students fairly; and 5) I feel safe in my school. A 5 point Likert scale is used (1=strongly agree, 5=strongly disagree). Summed scores were reverse-coded so that higher scores represented greater connectedness	See below. At the individual level, female and Black students generally report lower levels of school connectedness. Students from 2-parent families "feel slightingly more connected to school than do students in other family types. Coefficients for these demographic variables, however, are small relative to the effect sizes for age, grade-point average, participation in extracurricular activities, and skipping school. Together, individual-level and school-level covariates explain 10.9% of within-school variance." "four school attributes – classroom management climate, school size, severity of discipline policies, and rates of participation in extracurricular activities – explain a significant percent of between-school variance in school connectedness."	7-12th graders in 80 randomly selected high schools and a feeder school (usually a middle school). The final sample included 71,515 students in 127 schools	McNeely et al. (2002) *Journal of School Health*
Structural school characteristics					
School size	I	Measured in 100s	Increased school size is associated with decreased school connectedness (fairly weak association)		
Class size	I		Not associated with school connectedness		
Public school or private	I		Not associated with school connectedness		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
Urbanicity: Rural, urban or suburban	I		Not associated with school connectedness		
Student participation and classroom management					
% students not participating in extracurricular activities	I		Higher participation is associated with greater school connectedness		
Classroom management climate	I	4-item scale based on responses to "Since school started this year, how often have you had trouble: getting along with your teachers; paying attention in school; getting your homework done; getting along with other students (0=never; 4=every day)	More difficult classroom mgt climates associated with less school connectedness		
Discipline policies	I	Describes severity of punishment for first time occurrences. 3 measures of 1) whether students receive out-of-school suspension or expulsion the first time they are caught cheating; 2) whether students receive out-of-school suspension or expulsion the first time they are caught smoking; 3) a composite score of mean discipline policy for 10 other infractions.	"School connectedness is lower in schools that expel a student temporarily or permanently for infractions more serious than cheating or smoking." .		
Teacher qualifications	I	% first-year teachers; % teachers with Master's degree	% teachers in first year or with Master's degree not associated with average level of school connectedness		
Demographics	I	% 2 parent families; % Black; % Black squared; School more than 80% Latino	School connectedness is lowest in racially integrated schools		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
School characteristics				293 secondary schools in NJ	Fowler and Walberg (1991) *Educational Evaluation and Policy Analysis*
% minority	I	Black, Hispanic, Asian and Pacific Islanders, or American Indian (established by the Office of Civil Rights)	Not significant		
School enrollment	I	Total enrollment for all grades in 1984-1985	4th most consistent variable. Negatively associated with six outcomes. Retentions and several achievement test scores were higher in smaller schools		
Pupil/teacher ratio	I	Number of students per teacher, on average; total pupils/number teachers in school	Significantly related to at least one outcome variable		
% constructively employed	D	Number of follow-up students employed (including students attending college)/total number of students followed			
% unsuspended	D	1 - Students suspended/total enrollment			
% retained	D	1 – students excluded for administrative, discipline, behavior, or academic reasons/total enrollment			
% low income	I	Students in family with income below $10,686	Second most consistent variable. Significantly and negatively correlated with all but 4 outcome variables (constructively employed,		

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
			unsuspended, retained, and mean SAT verbal score)		
Teacher characteristics	I				
Average salary	I	School's average salary for 1984-85	Significantly related to at least one outcome variable		
Number of teachers	I	Total full-time certificated classroom teachers	Not significant		
% teachers with no degree	I	% certified to teach based on experience and certification in the filed rather than by degree (e.g., vocational ed)	Not significant		
% with BS	I	% reported to possess	Significantly related to at least one outcome variable		
% with Master's	I	% reported to possess	Not significant		
% doctoral	I	% reported to possess	Not significant		
% other degrees	I	Degrees from foreign countries or degrees otherwise earned, such as a nursing degree from a hospital program	Not significant		
Average experience in school	I	Average # years teaching experience within the school	Not significant		
Average experience in the district	I	Average # years teaching experience within the school district	Not significant		
Average experience in NJ	I	Average # years teaching experience within the state of NJ	Not significant		
Average experience in education	I	Average # years teaching experience within any state	Not significant		
Test characteristics	D	Minimum basic skill test: avg score reading/ math; % failing reading or math or both High School Proficiency Test: % passing			

Appendix A (cont'd).

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
		reading/math/writing; avg score reading/math/writing/multiple choice writing/essay writing. A total of 13 outcome variables here.			
School district characteristics	I				
District avg SAT verbal score	D				
District avg SAT mathematics	D				
District enrollment	I	Total number enrolled as of 9/30/84	Not significant		
# schools within a district	I	In 1984-85	3rd most consistent. Negatively associated with ten outcomes.		
Per-pupil expenditures	I	Actual costs of educating pupils within the local district in 1984-85 (central office admin; instruction; attendance; health services; transportation; operations; maintenance; food services; student body activities; special projects; federal charges; fixed charges)	Not significant		
District socioeconomic status	I	A principal-components analysis combined 7 variables from the 1980 census: educational level, occupational status; density; urbanization, income, unemployment and poverty. Standard score generated.	Significantly and positively associated with all but 1 (suspensions) of the 18 outcomes, with the other variables being controlled.		
Per-pupil property wealth	I	Equalized valuation (as of Oct 1, 1984)/#resident pupils enrolled as of Sept 30, 1984	Not significant		
Student performance/	D	Several studies reviewed, various measures of student achievement.		A review article. The conclusions are	McGuffey (1982) in

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
achievement				those of McGuffey, based on the studies reviewed. General conclusions: "(1) obsolete and inadequate school facilities detract from the learning process; modern, controlled physical environments enhance it and (2) facilities may have a differential impact on the performance of pupils in different grades and for different subjects"	Improvin g Education al Standards and Productivi ty
Physical Environment Variables					
Building age	I		7 studies. Building age has been shown to be a statistically significant variable affecting achievement. "Some variations existed with regard to impact on grade level or specific subject matter achievement scores."		
Thermal conditions	I		8 of 9 studies reviewed showed that thermal factors affected student performance/achievement		
Color and interior painting	I		5 studies. Findings are mixed and the studies reviewed were limited with respect to sampling and generalizability. Findings suggest		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
			that color affects student performance.		
Seeing factors	I		10 studies. Several studies demonstrated significant effects on students' visual performance		
Hearing factors	I		7 studies. "Although generalizability of the individual studies is questionable, there is little doubt that noise can create sufficient interference with verbal instruction to hinder learning."		
Building Configuration Variables					
Amount of space	I		2 studies reviewed, finding mixed		
Open space	I		9 studies reviewed. Studies on self-concept favored traditional schools, achievement studies were mixed.		
Windowless facilities	I		1 study. Little or no effect on academic performance		
Underground facilities	I		1 study. No difference in achievement, anxiety or attitude between above ground (with or w/o windows)		
Programmatic Variables					
Site size	I		3 studies on effects on achievement, performance and self-concept.. 2 showed small number of significant regressions		
Building utilization	I		1 study. No relationship with achievement		
Building maintenance	I		1 study. Attitude and behavior of students favored modernized		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
			building vs. older, poorly maintained building		
Support facilities	I	Such as libraries, auditorium, cafeteria	9 studies. Mixed findings		
Special instructional facilities	I	Presence of science labs	2 studies. "Both found a significant positive relationship between the presence of science laboratories and achievement."		
Size of school	I		16 studies. 5 showed + relationship between size and program offerings; 2 showed increased school size increased amount of space available for special instruction facilities; 3 showed size related to program quality, while one did not; 4 showed school size was a + significant factor in achievement, one did not.		
Student attitudes such as sense of obligation, sense of belonging, satisfaction, persistence, loneliness, self-esteem, feeling of control over one's life, use of psychoactive substances,	D		The paper examined conflicting claims regarding the ideal school size. Findings include "Large secondary schools, that is, those with a graduating class above 750 … seem to have untoward effects upon student attitudes, achievement, and voluntary participation. Such consistent findings among such a broad array of secondary student outcomes is troubling enough, but some researchers also suggest that these effects may persist into adulthood, if not into college attainment … Student achievement is enhanced by satisfaction with	A review article. Lists several student outcomes evaluated in the literature regarding school size and student outcomes.	Fowler (1995) School Size and Student Outcomes in *Advances in Educational Productivity*, *Volume 5*

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
truancy (cutting class and skipping school, disorder (vandalism and theft), educational aspirations, race relations			academic courses, with a low dropout rate, and through voluntary participation in extracurricular area, all of which are highly correlated with small secondary schools… Student achievement also was, on average, higher in smaller high schools. This finding is particularly true of poorly achieving students…However, the finding that student achievement is enhanced by small high school size was supported by the fewest studies, and so must be considered less robust than the findings for student attitudes, attendance, participation, and satisfaction."		
Student achievement Such as test scores, constructive employment, drop-out rate, college attendance, grade point average	D		See above		
Voluntary participation in extracurricular activities, including clubs, sports, political and	D		See above		

Variable	I/C/D	How Measured	Relationships to Other Variables	Subjects	Source
social involvement					
Enduring effects such as adult voluntary participation, participation in college extracurricular activities	D		See above		
School size	I	Enrollment	See above		

* I = Independent variable
C = Control variable
D = Dependent variable

APPENDIX B

CONCEPT MAPPING HANDOUT FOR EDUCATORS

Getting Started

Insert the floppy disk into the a: drive on the computer. Enter your username and password.

Username: uwg1 through uwg18 (use name on your disk, uwg is lower case)
Password: password

Step 1: Demographic Information

Please enter demographic information, as requested on screen

Step 2: Importance Ratings

Use the left and right arrow keys to navigate through the statements.
Enter the rating value (1, 2, 3,or 4) for each statement, pressing the Right Arrow key or the Enter key after each value to navigate to the next statement.

Step 3: Sorting Statements

Please group the statements into piles that make sense to you following these guidelines:

Group the statements for how similar in meaning they are to one another. You will be creating a main topic name for each pile you create. Do not group the statements according to how important they are, how high a priority they have, etc. Another part of the process will ask you how important you believe each idea is.

- There is no right or wrong way to group the statement. You will probably find that you could group the statements in several sensible ways. Pick the arrangement that feels best to you.
- You cannot put one statement into two piles at the same time. Each statement must be put into only one pile.
- People differ on how many piles they wind up with. In most cases, anywhere from 10 to 20 piles usually works out well.
- A statement may be put alone as its own pile if you think it is unrelated to the other statements or it stands alone as a unique idea, but you cannot have one pile for each statement.
- Make sure that EVERY statement is put somewhere. Do not leave any statements out.
- Do NOT create any piles that are “miscellaneous” or “junk” piles. If you have statements left over that you cannot place, put each statement in its own pile.

To create a new pile:

Click on a statement you wish to place in the new pile and dreg it off the statement palette, dropping it on some “clear” space.
A new pile window will open, allowing you to name the pile you are starting.
Enter a name for the new pile.
Click on OK. (The statement you dragged is now in the new pile.)
Click on Cancel to cancel the creation of the new pile.

To move a statement from one pile to another:

Appendix B (cont'd).

Open the "source" Pile Window by double-clicking on the Pile Icon. (The main Statements pile is the only pile that is open initially)
Click on the statement you want to move, and drag it over to the destination pile until the pile is highlighted. (Destination piles can be in the Icon or window state.)
Drop or release the statement while the pile is highlighted. (The statement is now in the pile.)

To rename or delete a pile:

Select the pile by clicking on it.
From the Piles menu, choose Rename Pile or Delete Pile. (Note: To delete a pile, it must be empty of statements)
To rename the pile, enter the new pile name.

To open or minimize all piles:

Click on Window → Open All Piles or Window → Minimize All Piles menus.

Appendix B (cont'd).

#	Statement
1	Attendance
2	Attitudes
3	College-related variables (such as admission to college)
4	Individual student affective performance (includes self-concept, attitudes toward Peers/school/teachers, self-efficacy of learning, feeling of homework overload and intention to drop out)
5	Interpersonal relations with other students and school staff
6	Language acquisition
7	Level of extracurricular participation
8	Mathematics achievement
9	Off-task behavior
10	Phonemic awareness through primary grades
11	Reading skills
12	Retention (students who have not dropped out of school)
13	School connectedness (students feel cared for and feel like a part of the School)
14	Student achievement
15	Student attitudes toward their school
16	Acceptable student behavior
17	Student performance
18	Student self-concept
19	Student social development
20	Asthma
21	Asthma
22	Arthritis
23	Fibromyalgia
24	Back pain
25	Tutoring
26	After and before school programs
27	Extracurricular enrichment activities
28	Buildings and grounds clean and well maintained
29	Resources are well maintained and up to date
30	Support services are provided (paraprofessionals, secretarial, etc)
31	Teacher/administrator retention
32	Teacher/administrator absentee rates
33	Teacher/administrator graduate degrees
34	Teacher/administrator feelings of efficacy
35	Teacher/administrator years of experience
36	Teacher/administrator participation in professional development
37	Teacher/administrator levels of collaboration
38	Teacher/administrator general levels of satisfaction
39	Teacher/administrator special awards, honors, or accomplishments
40	Teacher/administrator participation in professional organizations
41	Teacher/administrator complaint hearings
42	Teacher/administrator disputes
43	Teacher/administrator lawsuits
44	Teacher/administrator disciplinary actions
45	Teacher/administrator referrals for counseling
46	Teacher/administrator levels of evaluation
47	Teacher/administrator mental health concerns
48	Incidences of workmen's compensation
49	Incidences of use of counseling services by teachers/administrators

Appendix B (cont'd).

50	Estimated amount of money teachers spend out-of-pocket on school expenses
51	Parental Satisfaction
52	Involvement in Community Service Projects
53	Public Relations
54	Students who are "team players"
55	General and Special Education Cohesiveness
56	Student attitude toward physical activity and lifelong fitness
57	Student short-term post secondary goals attained
58	Student satisfaction with post secondary preparation
59	Community Business satisfaction with student employees and graduate employees
60	Community involvement
61	Socioeconomic status
62	Movement to different schools during school career
63	School size/enrollment
64	Average class size (not teacher:student ratio)
65	Length of time 'in-country' for immigrant students
66	Multiple retentions
67	Graduation Test score performance
68	SAT scores - school
69	SAT scores - student
70	ACT scores - school
71	ACT scores - student
72	Graduates enrolled in college (Admission does not necessarily mean enrollment....)
73	Joint enrollment participation levels
74	Experience/educational level of teaching staff
75	Alternative school placement
76	Advanced Placement offerings
77	Advanced Placement enrollment
78	Advanced Placement test scores
79	National Merit Scholar program results
80	Governor's Honors participation
81	In-school discipline suspensions
82	Out-of-school discipline suspensions
83	Community involvement
84	Parental involvement
85	Parent resource centers
86	Parenting workshops
87	Creativity
88	Academic growth
89	Special talents
90	Postgraduate study and success
91	Feedback from the community and alumnae
92	Interest in continuing education
93	Student perceptions
94	Sense of community
95	Student/teacher interaction in the learning environment
96	Student friendly environment
97	Staff development
98	Teacher mentoring
99	Staff level of academic achievement

Appendix B (cont'd).

100 Availability of materials and other resources
101 Teach/Assess/Reteach cycle
102 Teacher verbal ability
103 Teacher support (i.e., induction program, availability of instructional leadership like An ILT, etc.)
104 Vertical teaming within the school and with feeder schools, as well as schools that students feed into
105 Standardized test scores (appropriately used)
106 Participation in PHS courses
107 Student transience rate
108 Occurrence of discipline consequences

APPENDIX C

CONCEPT MAPPING RESULTS

Measures of Student, School and School District Success

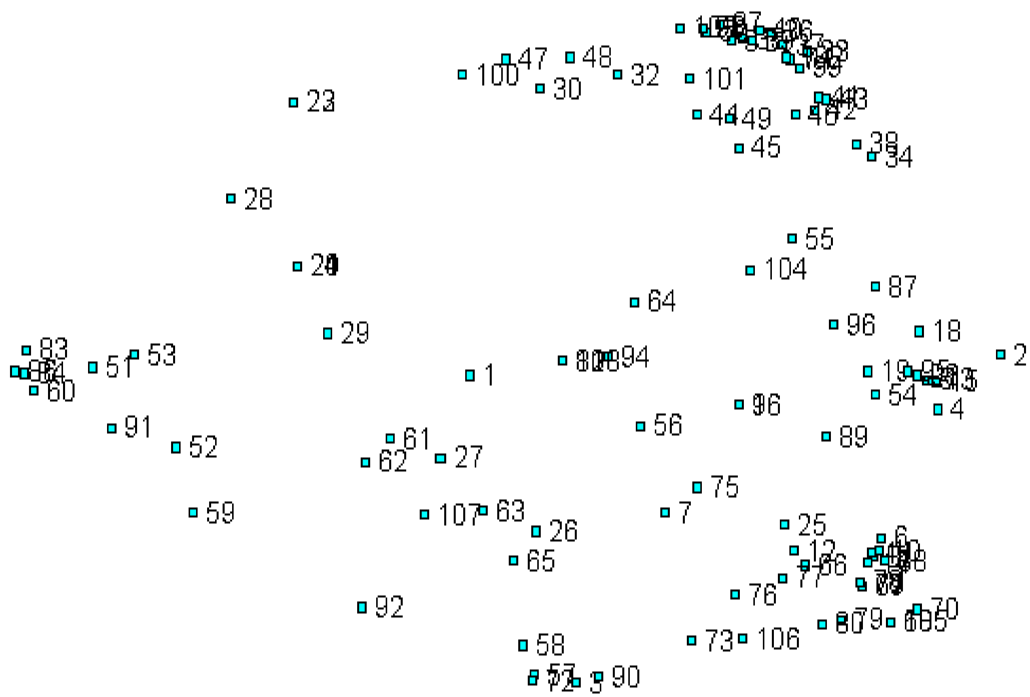
Results from a Concept Mapping Exercise

University of West Georgia

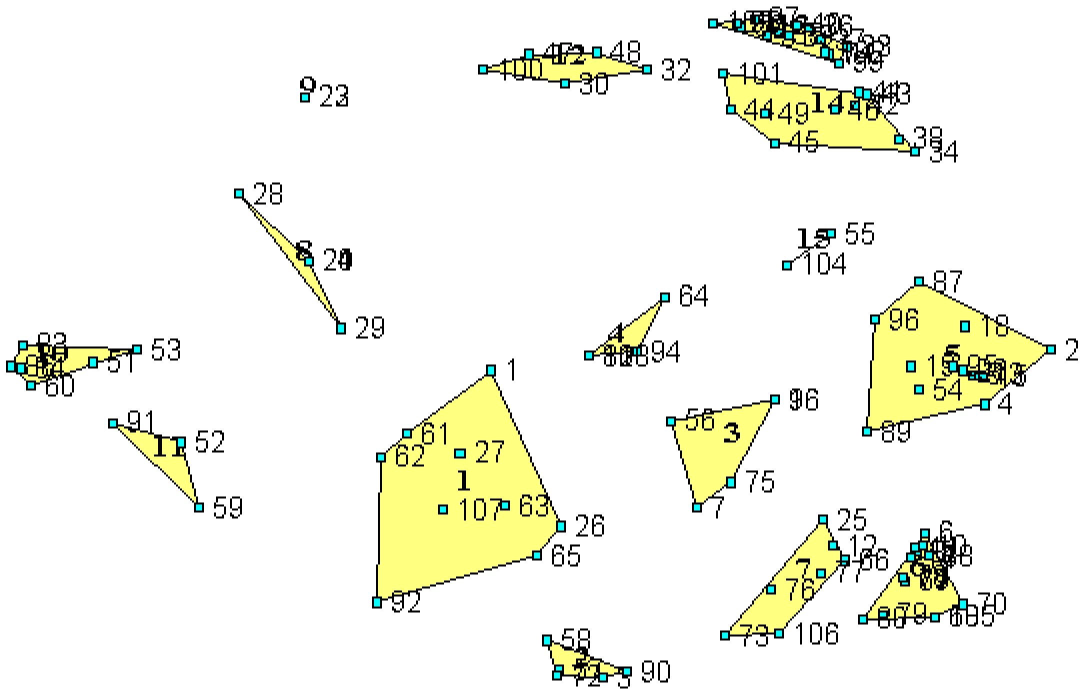
January 21, 2003

Appendix C (cont'd).

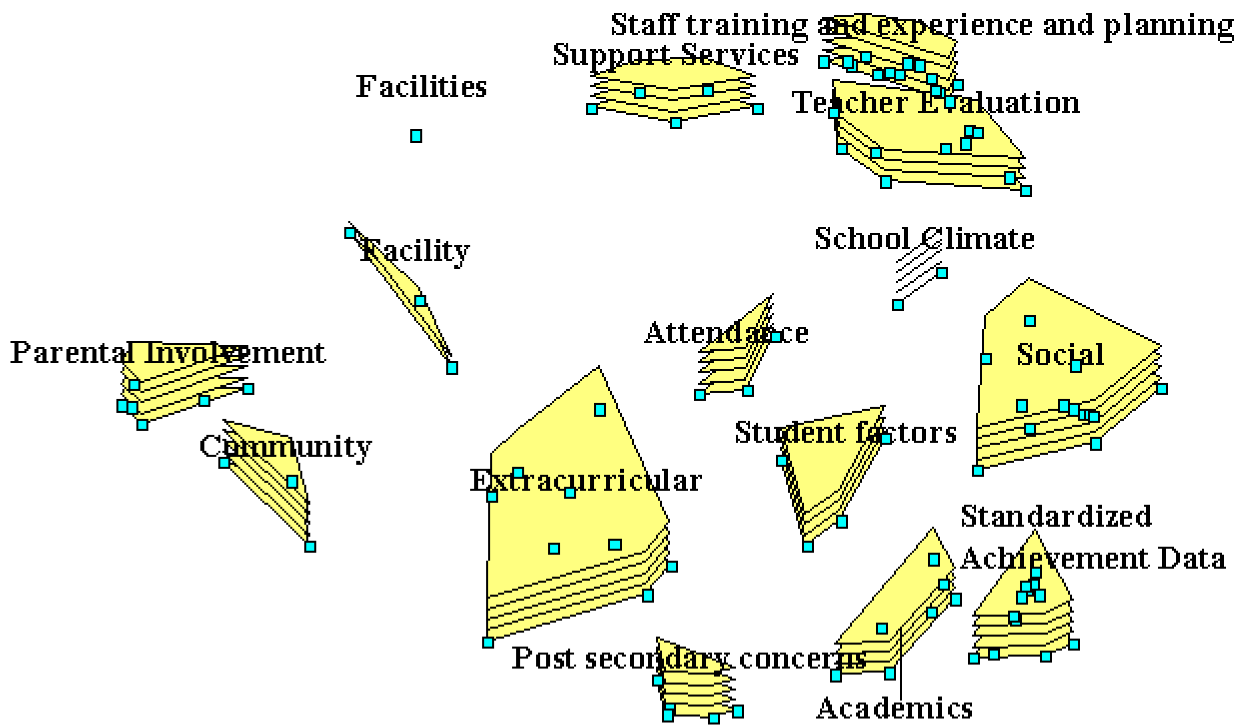
Point Map



Cluster Map: 15 Clusters



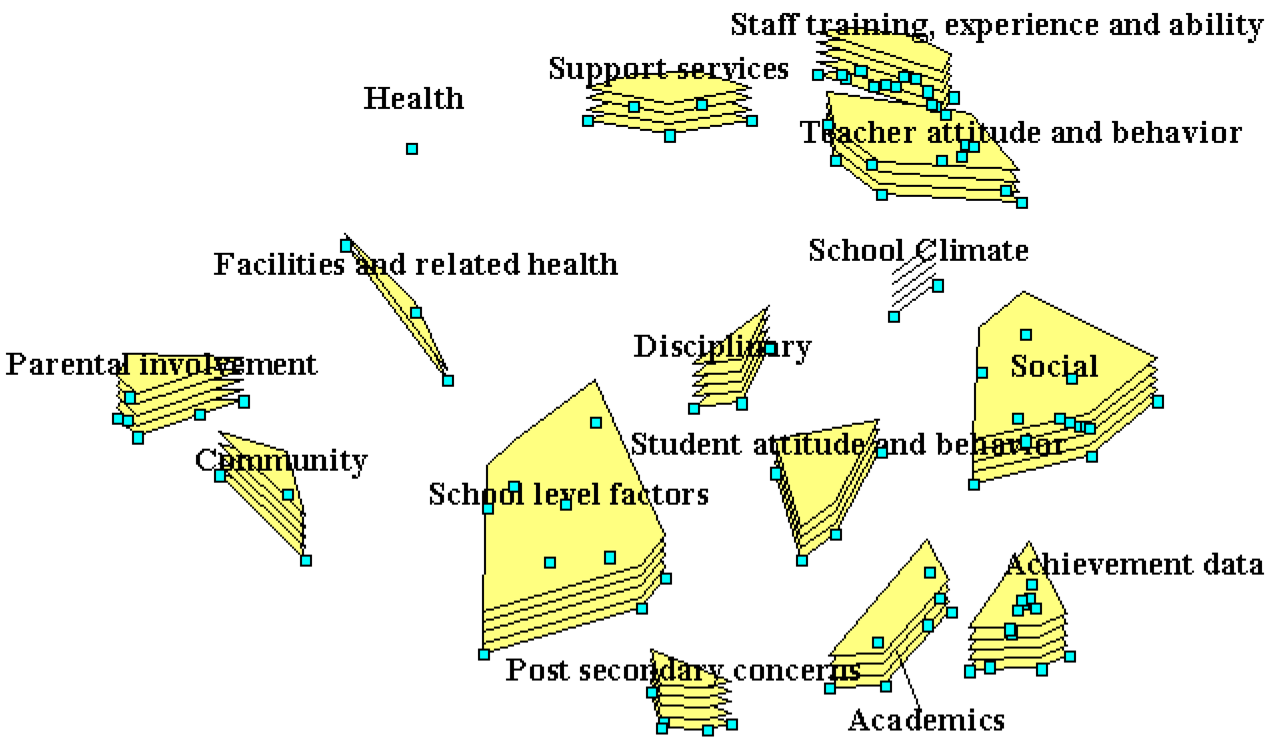
Cluster Rating Map With Labels: 15 Clusters



Why 15 Clusters?

- Reviewed many different numbers of clusters
- Less than 15 seems not to differentiate enough
- More than 15 creates new clusters not distinctly different from those from which they came.

Recommended (by facilitator) Cluster Labels



Recommended Cluster Label Changes

- Extracurricular → School level factors
- Student factors → Student attitude and behavior
- Attendance → Disciplinary
- Standardized achievement data → Achievement data
- Facility → Facilities and related health
- Facilities → Health
- Staff training and experience and planning → Staff training, experience and ability
- Teacher evaluation → Teacher attitude and behavior

Top Rated Clusters

- Achievement data (3.25)
- Parental involvement (3.14)
- Community (3.12)
- Postsecondary concerns (3.09)
- School climate (3.09)
- Staff training, experience and ability (3.08)
- Disciplinary (3.08)

Lowest Rated Clusters

- Health (1.50)
- Facilities and related health (2.13)
- Teacher attitude and behavior (2.66)

Appendix C (cont'd).

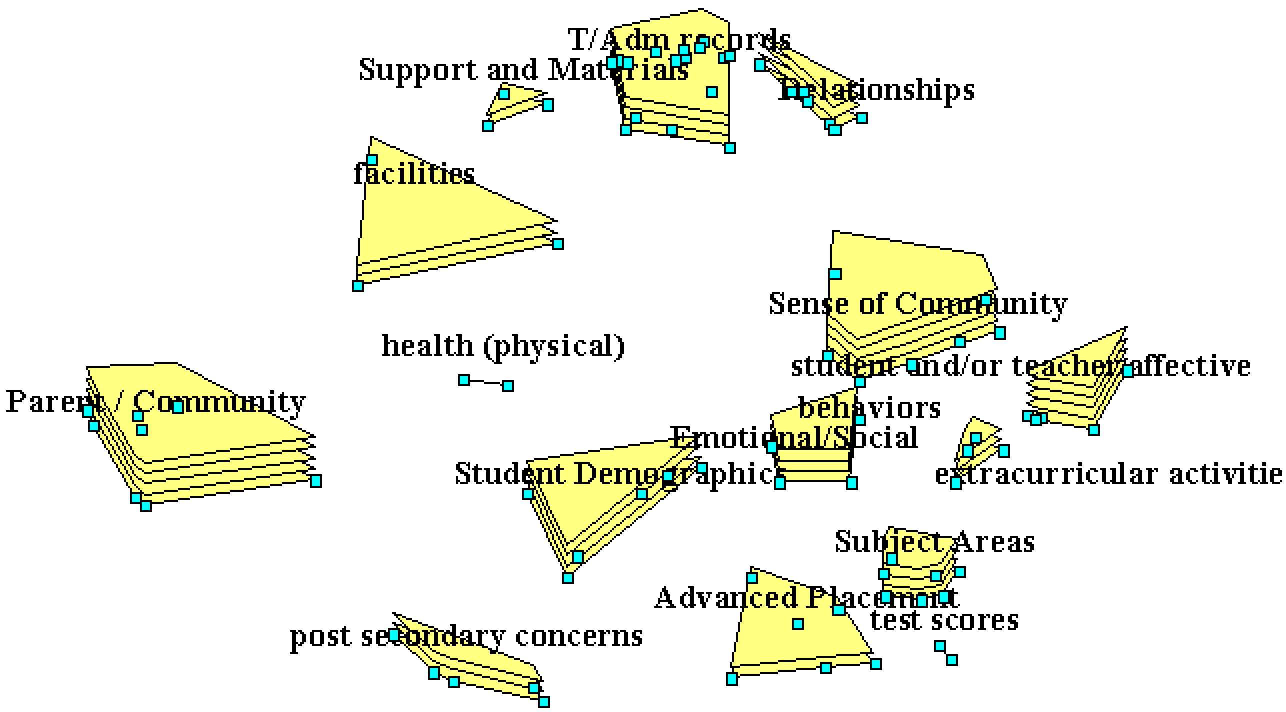
Top Rated Statements

- Reading skills
- Attendance
- Staff development
- Mathematics achievement
- Parental involvement
- Language acquisition
- Student achievement
- Student performance
- Teacher/administrator retention
- Academic growth

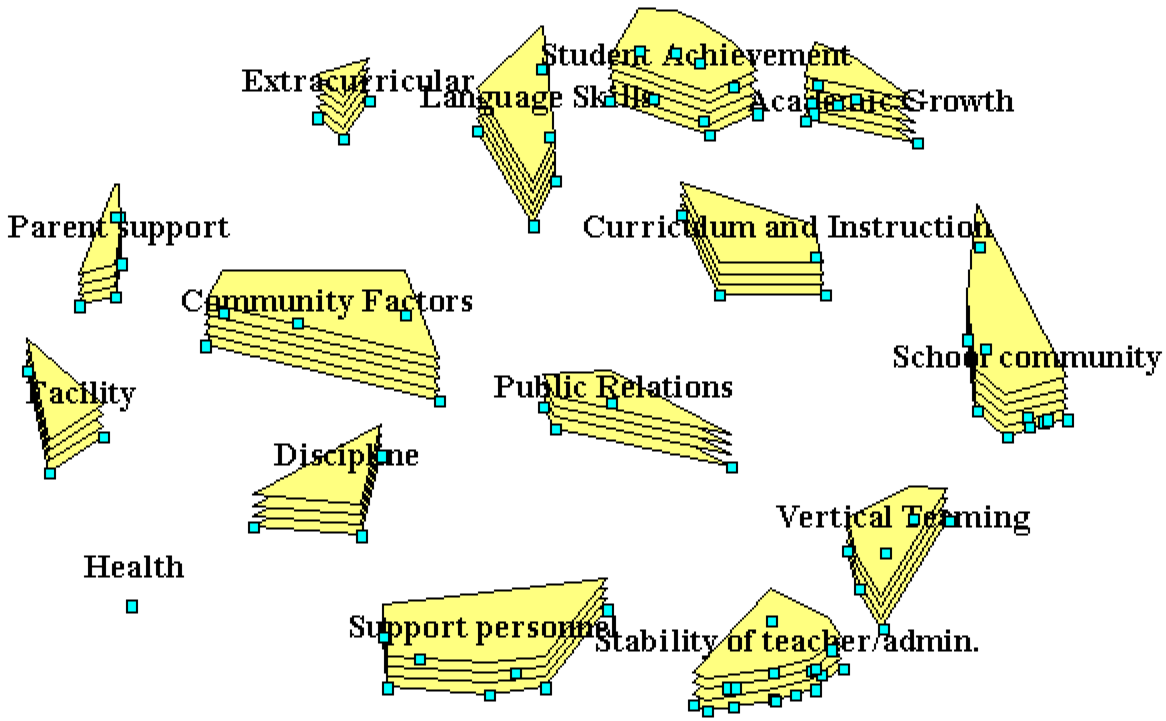
Lowest Rated Statements

- Asthma
- Back pain
- Fibromyalgia
- Arthritis
- Asthma
- Incidences of workman's compensation
- Incidences of use of counseling services by teachers/ administrators
- Estimated amount of money teachers spend out-of-pocket
- Teacher/administrator mental health concerns
- Teacher/administrator participation in professional organizations

Teachers, Counselors and Other: 15 Clusters



Administrators: 15 Clusters



APPENDIX D

LESSONS LEARNED FROM CONCEPT MAPPING EXERCISE

There were some important lessons learned from using this method that may improve the process for other researchers who may wish to replicate this study or apply the method in another similar study. The primary lessons learned occurred during the brainstorming exercise and the sorting/rating activity, as described below.

Brainstorming

The brainstorming exercise would likely be more effective if conducted in-person. Once the group was gathered for the sorting and rating exercise, there was a discussion to clarify some of the statements derived from the brainstorming activity. For example, the concept of "retention" was confusing because the study from which this concept was derived used the term to mean that students stayed in school rather than dropped out, but the educators associate the term with holding students back in the same grade or course. Regarding the measure of "teacher referrals for counseling" one asked whether that meant teachers getting referred for counseling or teachers referring students? The general consensus was that this addresses teachers referring students for counseling. A term that the researcher did not understand (although the educators were clear about this) was "vertical teaming" which refers to collaboration between elementary, middle, and/or high schools, or even between grade levels within a school to ensure that expectations about what students have learned in the previous grade or course are appropriate. Teachers consult on curricula to ensure that students are prepared for material in future grades. There was quite a bit of confusion about these and other terms, which could have been clarified before the list was locked (i.e., could no longer be modified using the software).

During the discussion, one participant asked whether items could be added to the list during the session. Unfortunately, the list had already been locked. These kinds of clarifications could have been addressed by allowing last-minute addition of list items (which the software does not permit), or by having done the brainstorm in real time. The researcher would have preferred to conduct the brainstorming in person, but the time constraint of two and a half hours for the course made this impossible without asking the course instructor to provide an additional time for this exercise, which seemed unreasonable to the researcher. Another round on-line may have helped reduce some of the confusion as well.

Sorting and Rating

Following the sorting and rating exercise, participants were then asked “what bugged you about this process”? One person mentioned that there were so many statements that it was easy to get tired and that she had a hard time coming up with new categories. Toward the end, it became easier to just put things in their own categories. Another person stated (and others agreed) that the software makes it hard to read the names of the clusters that were created because the title bar in too short. Participants had to click on the cluster to see the complete name and this should not be necessary. When asked what terms they had a difficult time sorting and rating, participants responded with the following:

- Creativity – whose? Teacher, students, others?
- Special talents – who? Teacher? Student? What kind of talents?
- Students who are team players – what does “team player” mean? Someone who works well in groups? Good leaders (e.g., student government)? Members of sports teams, such as football?
- Language acquisition – because this occurred in the list near the statement “Length of time 'in-country' for immigrant students,” some interpreted this as a statement about foreign students. Did this statement refer to all students?
- Teacher verbal ability – does this refer to clarity, how articulate, ability to use language? There is also a possible a cross-cultural component to this also. What's the match between the student's culture and the teacher's culture?
- Retention – previously discussed.

The participants would have liked more clarification of some of these statements or even an example. When asked about what they liked about the process, the participants emphasized that the software was easy to use and that the exercise went quickly and quietly. One mentioned that it was not as difficult as she first thought it would be when looking at the list. Others agreed. They thought the software greatly facilitated the process. The participants had at some time in the past completed a concept mapping exercise using manual card sorting during a qualitative research methods course at the State University of West Georgia. They expressed dissatisfaction with that activity, but it certainly made them familiar with the concept mapping methodology.

Proximity of terms on the initial list may have seriously influenced the sort, which may have been mitigated by randomly sorting the list items. Proximity of statements to one another on the list may have helped participants understand what terms meant, but it may also have biased their interpretation.

The goals of Phase II were met successfully. Through the use of concept mapping, the highest priority measures of success were identified for use in Phase III. The greatest frustration for the researcher has been that the measures of success identified by the educators did not seem to be dependent variables, as hoped for. Several items, such as socioeconomic status, are more often seen in the literature as independent or control variables. Although a variable such as socioeconomic status may, in some way, indicate "success," it was not the type of dependent measures sought since the school facility cannot affect such a variable. However, from the entire list of measures of success, many of them are the types of variables that may plausibly be affected by the physical school facility.

Phase II resulted in a list of measures of student, school or school district success, rated by educators for how important it is to monitor or otherwise track each measure. These measures were clustered into fifteen categories. In Phase III, a group of SFE researchers were asked to identify physical variables (e.g., team workstations, building condition) that are plausibly related to those measures of success, focusing on those that were most highly rated. Chapter 5 describes Phase III of this research.

APPENDIX E

INVITATION TO PARTICIPATE IN THE DELPHI STUDY

Dear _________________,

As a recognized researcher in the field of school facility effects on educational outcomes, I believe that your knowledge and experience will provide invaluable information for a critical phase of my doctoral research at the Georgia Institute of Technology, College of Architecture. The investigation is entitled *Identifying the Relevant Variables for Understanding the Effects of School Conditions on Educational Outcomes,* and I will be THRILLED if you are willing to participate!

During this phase of my work, a group of experts and experienced researchers will participate in a series of four surveys to identify the most plausible links between school facilities and educational outcomes (e.g., academic achievement, behavior) for the purpose of recommending a research agenda for this field. You will also be asked to suggest methods for measuring a sub-set of these variables to perhaps guide future research in such a way that meta-analysis of school facility effects research becomes more plausible. The surveys are described below:

Survey 1: Brainstorm a list of physical school conditions that likely affect educational outcomes. [Approximately 30 minutes. Due March 28]

Survey 2: Identify plausible relationships between school conditions and educational outcomes that educators believe are important. [Approximately 1 to 1½ hours. Due April16]

Survey 3: Participate in a second round on Survey 2 to gain some level of consensus [Approximately 30 minutes. Due April 30]

Survey 4: Recommend operational definitions or methods for measuring a subset of the variables identified in Survey 2. [Approximately 45 minutes to 1 hour. Due May 14]

I realize that you are very busy, but I hope you agree with me that our work together on this project has merit and will make a valuable contribution toward improving our understanding of how school facilities affect teaching and learning.

I have attached Survey 1. Please send your "brainstorm" response via e-mail to me at sheila.bosch@gtri.gatech.edu by March 28, 2003.

THANK YOU, in advance, for assisting in my research. I look forward to working with you and will provide you with any additional information about this project you request. Also, I will be happy to send you a PDF of the results of this phase of my study, or my entire dissertation when completed, if you so desire. Please feel free to call me if you have any questions about this study, or if you would just like to exchange ideas and information on this topic.

Sincerely,

Sheila Bosch
Georgia Institute of Technology
404-894-8046

APPENDIX F

RESEARCHER QUESTIONNAIRE 1

Please brainstorm a list of physical conditions in schools that you believe, based on your knowledge and experience, likely affect educational outcomes (e.g., academic achievement, behavior, teacher performance). The list below, derived from the literature, is designed to give you an idea of the types of variables sought in this research project. You may add to this list or simply generate your own. Please return your list to sheila.bosch@gtri.gatech.edu **no later than March 28, 2003.** Your list will be combined with other experienced researchers and used in Survey 2. THANK YOU!

Physical Conditions Likely to Affect Educational Outcomes:

Acoustics
Aesthetics and appearance
Age of the school building
Aircraft noise
Animal life on premises
Building maintenance
Building renovations
Class size
Classroom adaptability
Climate control
Daylighting
Full-spectrum lighting
Green areas/living views
Indoor air quality
Natural ventilation
Outdoor rooms or spaces
Perceived quality of classroom's physical environment
Presence of absence of fluorescent lighting
Presence or absence of air conditioning
Presence or absence of carpet
School building condition
School enrollment/size (not square footage)
Sensory stimulation
Site size
Thermal factors
Type of air conditioning
Type of artificial lighting
Underground facilitiesVisual factors (broader than just lighting conditions, such as contrast between print and paper)
Visual stimulation
Wall color
Windows (presence or absence, type)

APPENDIX G

FRAMEWORK OF PHYSICAL VARIABLES PLAUSIBLY RELATED TO EDUCATIONAL OUTCOMES: VERSION 1

FUNCTIONALITY

Wayfinding/ movement through building

Signage
Grade configuration
Relationship of spaces within building

Crowdedness or spaciousness

Overcrowded conditions (possibly determined by % capacity for school achieved, square foot per child in the classroom)
Circulation spaces and patterns that do not force hundreds or thousands of students into narrow, long spaces

Flexibility

Site (e.g., size, types of uses)
School building (e.g., for additions or renovations, for adaptive reuse)
Classroom (e.g., walls, equipment)
Seating (comfortable and flexible, allows different seating configurations)
Work surfaces (adequate surfaces of different heights, sizes and shapes to support work)
Fluidity of seating and work surfaces to meet shifting and immediate needs
Adequate and well-placed electric outlets

Privacy

Spaces for quiet reflection (however created – furnishings, walls, doors, etc.)

Collaboration and social interaction

Convenient and secure storage of collective projects in process
Acoustic privacy from other groups
Autonomy of access to group work area (allows team members to work on projects as mood strikes)
Presentation area – present acquired knowledge, skills and abilities
Team workstations/shared spaces
Faculty collaborative space
A building of niches (allows many small groups to claim space and meet in regular locations)
A town square (large area all pass though-promotes casual contact)
Commons areas appropriate for age group
Display space and studios for ideas, processes, projects and products (including tack surfaces)
Informal learning spaces where students, teachers, and staff can continue learning beyond the confines of the “classroom”
Spaces to accommodate different size groups
Conference spaces
Absence of "departments"
Interior windows for visibility of learning process
Spaces for design, production, and testing and evaluation, and application of products

Appendix G (cont'd).

Diversity of Activities

Music rooms
Science laboratories
Physical education facilities
Professional spaces for teachers (including work rooms, lounges, offices, professional library)
Outdoor learning spaces (natural, man-made)
Food service areas

Spatiality and Scale

Site size
School building size (e.g., square footage, does it allow for school within a school or learning "houses" if large school?)
Classroom size (square footage)
Classroom shape
Relative scale of building elements

Ownership and control

Individual workspace (student "owned," allows a quiet home base, control of the modes of work)
Lockable, personalized storage
Student accessible files (students create and maintain an individual learning plan, portfolio of learning evidence)
Spaces for students to personalize
Multiple access points and time availability to food and beverages
Control over interior thermal, visual and acoustical conditions

COMFORT, HEALTH & SAFETY

Acoustical comfort

Interior noise (e.g., ambient, classroom)
External noise (e.g., aircraft, highway)

Visual comfort

Natural lighting (e.g., windows, clerestories, skylights)
Electric lighting (overhead, task)
Views to the outside
Contrast between print and paper

Thermal comfort

Air-conditioning (e.g., presence, type)
Heating
Individual control over thermal conditions (e.g., ventilation, temperature)

Indoor air quality

Adequate ventilation
Presence or absence of pollutants indoors (e.g., mold, VOCs)
Cleanliness

Appendix G (cont'd).

Safety and security

Site lines within building
Telephones in classroom
Child's perceived safety

AESTHETICS & APPEARANCE

Visible conditions

Perceived cleanliness (may be affected by condition of student toilets, etc.)
Perceived quality of classroom condition
Appearance of walls (e.g., deteriorating plaster, water stains, frequency of painting)
Age of the school building
Building improvements/modernization
Sensory stimulation
Floor coverings
Wall coverings or treatments
Colors

Building legibility

Integration of culture into design
Integration of student work into design

RESOURCES

Community Resources

Visitors easily accommodated (parking, access, work areas)
Location in residential, urban/commercial or industrial area
Community, business, volunteer, and parent space within the facilities
Learning spaces in the community - shared spaces such as libraries, physical fitness centers, museums,
Small business incubator space

Technology Resources (students and staff)

Internet access
Autonomous access to computer and library materials
Phone, copiers, fax – especially important if students are working with business and community partners in producing "real world" solutions

Human Resources (within the school)

Access to intellectual advice (implies faculty offices with ability to house one or a handful of visiting students)
Counselors among students (college and career advice available without special trip through unwelcoming administrative territory)
Adult-student spatial integration that keeps teachers from retreating into adult "ghettos" where they never have to contact kids, and into which kids are not welcome.

APPENDIX H

RESEARCHER QUESTIONNAIRE 2

SURVEY 2: PHYSICAL FACTORS

Please complete this survey by May 6, 2003

In the spirit of the Delphi method, the responses obtained from all panel members for Survey 1 have been summarized and are presented to you in this survey. You have provided a great list of physical factors plausibly related to educational outcomes. A framework for these factors has been developed using a 3-tiered approach. The broadest level includes 4 FEATURES (Functionality; Comfort, Health & Safety; Aesthetics & Appearance; and Resources), each including ELEMENTS and ITEMS (the most specific level in the framework).

In Survey 2, you are asked to complete 3 different types of tasks. Please respond only to the questions that you are comfortable answering, based on your personal knowledge and experience. First, comment on the framework that has been established to categorize the physical factors (comment boxes are included throughout the survey).
Second, rate the specific ITEMS using the following scale.

1 = Not important
2 = Somewhat important: Plausibly affects educational outcomes, but little to no research-based evidence exists.
3 = Important: Some evidence suggests it affects educational outcomes, but we still don't understand those effects well.
4 = Very important: Strong evidence exists, but we still don't understand those effects well

Please feel free to include comments about existing evidence or to elaborate on your ratings in the comments boxes.

Third, you will be asked to rate the relative importance of ELEMENTS and FEATURES as described below. In total, you will be asked to rate a few items within each of the 19 Elements and to relatively rate 4 sets of Elements and one set of Features. Please note that the survey will "time out" after some period of time (more 60 minutes, for certain) and the data you have entered will be lost. Please complete the survey in one sitting. This should take approximately 30 minutes (it took 20 minutes for one "pilot tester").
You may notice that a few of the physical factors from the original list or from those you submitted have been omitted from the framework. These (e.g., autonomy over time, animal life on premises, class size) did not appear to be physical factors in the same sense as the others. Also, you may have suggested that an item be omitted, but see it on the list. This is so that every panel member will have the opportunity to rate its importance (even if it is low). I will be happy to provide you with a list showing how the raw data have been transformed, categorized and omitted, upon request.

Please remember that there will be 2 additional surveys to complete this process. I will be providing all participants with a copy of the results of this Delphi study (or a PDF of my final dissertation, if requested). Thank you for your participation!!!!!

TASK 1

The following elements and items are categorized under the broader feature called FUNCTIONALITY. The items listed here likely do not capture all important items under each Element, but represent those provided in Survey 1. You may suggest additions, if you like. However, we can deal with this in a later survey as well when we begin to focus on those specific Elements that the group rates as being most important for future research.

Appendix H (cont'd).

Wayfinding/movement through building

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Signage (architectural, directional)				
Grade configuration				
Relationship of spaces within building				

Comments:

Crowdedness or spaciousness

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Overcrowded conditions (e.g., the school does not appropriately accommodate the enrollment, spaces do not appropriately accommodate users)				
Circulation spaces that do not force many students into narrow, long spaces				

Comments:

Flexibility

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Site (e.g., the site provides for multiples types of uses, is adaptable over time to suit changing needs)				
School building (e.g., The building allows for renovations/additions or adaptive reuse over time)				
Classroom (e.g., walls, equipment)				
Seating (comfortable and flexible, allows different seating configurations)				
Work surfaces (adequate surfaces of different heights, sizes and shapes to support work)				
Fluidity of seating and work surfaces to meet shifting and immediate needs				
Adequate and well-placed electric outlets				

Comments:

Privacy

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Spaces for quiet reflection (however created - walls, furnishing, doors, partitions, etc.)				

Comments:

Collaboration and social interaction

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Convenient and secure storage of collective projects in process				
Acoustic privacy from other groups				

Appendix H (cont'd).

Autonomy of access to group work area (allows team members to work on projects as mood strikes)				
Presentation area where students can present acquired knowledge, skills and abilities				
Team workstations/shared spaces				
Faculty collaborative spaces (where faculty across disciplines can plan together)				
A building of niches (allows many small groups to claim space)				
A town square (large area all pass through, promotes casual contact)				
Commons areas appropriate for age groups				
Display space and studios for ideas, processes, projects and products				
Informal learning spaces where students, teachers and staff can continue learning beyond the confines of the "classroom"				
Conference space				
Spaces to accommodate different size groups				
Absence of "departments" (allows cross-disciplinary faculty collaboration)				
Interior windows for visibility of learning process				
Spaces for design, production, testing and evaluation, and application of products				

Comments:

Diversity of activities

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Music rooms				
Science labs				
Physical education facilities				
Outdoor learning spaces (natural, manmade)				
Professional spaces for teachers (including work rooms, lounges, offices, professional library, storage of supplies)				
Food service areas				

Comments:

Spatiality and scale

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Site size				
School building size (e.g., square footage, does it allow for school within a school?)				
Classroom size (e.g., square footage)				
Classroom shape				
Relative scale of building elements				

Comments:

Appendix H (cont'd).

Ownership and control

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Individual workspace (student "owned," allows a quiet home base, control of the modes of work)				
Lockable, personalized storage				
Student accessible files (students create and maintain an individual learning plan, portfolio of learning evidence)				
Spaces for students to personalize				
Multiple access points and time availability to food and beverages				
Control over interior thermal, visual and acoustical conditions				

Comments:

The following items and elements are categorized under the broader feature called COMFORT, HEALTH & SAFETY

Acoustical comfort

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Interior noise (e.g., ambient, classroom)				
Exterior noise (e.g., from aircraft, highway, etc)				

Comments:

Visual comfort

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Natural lighting (e.g., windows, clerestories, skylights)				
Electric lighting (overhead, task)				
Views to the outside				
Contrast between print and paper				

Comments:

Thermal comfort

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Air-conditioning (e.g., presence, type)				
Heating				
Individual control over thermal conditions (e.g., ventilation, temperature)				

Comments:

Indoor air quality

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Adequate ventilation				

Appendix H (cont'd).

Presence or absence of pollutants indoors (e.g., mold, VOCs)				
Cleanliness				

Comments:

Safety and security

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Site lines within building				
Telephones in classroom				
Child's perceived safety				

Comments:

The following items and elements are categorized under the broader element of Aesthetics & Appearance

Visible conditions

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Perceived cleanliness (may be affected by condition of student toilets, etc.)				
Perceived quality of classroom conditions				
Appearance of walls (e.g., deteriorating plaster, water stains, frequency of painting)				
Age of the school building				
Building improvements/modernization				

Comments:

Sensory stimulation (visual, olfactory, tactile, auditory)

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Colors				
Floor coverings				
Wall coverings or treatments				

Comments:

Building legibility

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Integration of culture into design				
Integration of student work into design				

Comments:

The following items and elements are categorized under the broader feature called RESOURCES

Community resources

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Visitors' accommodations (parking, access, work areas)				

Appendix H (cont'd).

Location in residential, urban/commercial or industrial area				
Community, business, volunteer, and parent space within the facilities				
Learning spaces in the community - shared spaces such as libraries, physical fitness centers, museums				
Small business incubator space				

Comments:

Technology resources (students and teachers)

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Internet access				
Autonomous access to computer and library materials				
Phone, copiers, fax - especially important if students are working with business and community partners in producing "real world" solutions				

Comments:

Human resources within school

	Not Important	**Somewhat Important**	**Important**	**Very Important**
Access to intellectual advice (implies faculty offices with ability to house one or a handful of visiting students)				
Counselors among students (college and career advice available without special trip through unwelcoming administrative territory)				
Adult-student spatial integration that keeps teachers from retreating into adult "ghettos" where they never have to contact kids, and into which kids are not welcomed				

Comments:

Appendix H (cont'd).

TASK 2

YOU ARE NEARING THE END! Please distribute 100 points among the following ELEMENTS of FUNCTIONALITY showing their relative importance in future research to help us better understand the relationships between school facilities and educational outcomes. Rate them based on how important it is that they be done well (better than average). The total must equal 100.

________ Wayfinding

________ Crowdedness or spaciousness

________ Flexibility

________ Privacy

________ Collaboration and social interaction

________ Diversity of activities

________ Spatiality and scale

________ Ownership and control

Comments:

Please distribute 100 points among the following ELEMENTS of COMFORT, HEALTH & SAFETY showing their relative importance in future research to help us better understand the relationships between school facilities and educational outcomes. The total must equal 100.

________ Acoustical comfort

________ Visual comfort

________ Thermal comfort

________ Indoor air quality

________ Safety and security

Comments:

Please distribute 100 points among the following ELEMENTS of AESTHETICS & APPEARANCE showing their relative importance in future research to help us better understand the relationships between school facilities and educational outcomes. The total must equal 100.

________ Visible conditions

________ Sensory stimulation

________ Building legibility

Comments:

Please distribute 100 points among the following ELEMENTS of RESOURCES showing their relative importance in future research to help us better understand the relationships between school facilities and educational outcomes. The total must equal 100.

________ Community resources

________ Technology resources

________ Human resources within school

Comments:

Your name: ____

Questionnaire 2 Results

SECTION I

FUNCTIONALITY	IMPORTANCE RATING (1 = NOT IMPORTANT; 4 = VERY IMPORTANT)																AVG IMPORTANCE	SD
	Responses from 16 Panel Members																	
WAYFINDING/MOV'T THROUGH BLDG																		
Signage	2	3	4	2	2	1	2	2	4	4	2	3	2	3		1	2.47	0.99
Grade configuration	3	1	2	1	2	4	2	1	4	4	1	2	3		2	3	2.33	1.11
Relationship of spaces within building	3	4	3	4	2	3	2	3	4	4	3	3	4	3	3	3	3.19	0.66
CROWDENESS OR SPACIOUSNESS																		
Overcrowded conditions (possibly determined by % capacity for school achieved, square foot per child in the classroom)	4	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4	3.88	0.34
Circulation spaces and patterns that do not force hundreds or thousands of students into narrow, long spaces	3	4	3	4	3	2	2	2	4	4		2	3	2	4	2	2.93	0.88
FLEXIBILITY																		
Site (e.g., size, types of uses)	3	2	3	3	3	4	1	2	4	4		2	2	3	3	2	2.73	0.88
School building (e.g., for additions or renovations, for adaptive reuse)	4	3	3	3	3	3	1	2	4	4	2	3	4	3	4	2	3.00	0.89

Appendix I (cont'd).

Classroom (e.g., walls, equipment)	3	3	3	3	4	3	2	4	4	4	3	4	4	2	4	4	3.38	0.72
Seating (comfortable and flexible, allows different seating configurations)	4	3	4	4	4	4	3	3	4	4	3	3	3	3	3	3	3.44	0.51
Work surfaces (adequate surfaces of different heights, sizes and shapes to support work)	3	2	4	4	4	3	3	3	4	4	3	3	3	3	2	3	3.19	0.66
Fluidity of seating and work surfaces to meet shifting and immediate needs	4	3	4	3	4	3	3	1	4	4	2	3	4	4	3	4	3.31	0.87
Adequate and well-placed electric outlets	2	3	3	4	3	3	1	4	4	4	2	2	3	4	3	2	2.94	0.93
PRIVACY																		
Spaces for quiet reflection (however created – furnishings, walls, doors, etc.)	4	4	4	3	3	3	3	1	4	4	3	3	4	4	2	4	3.31	0.87
COLLABORATION & SOCIAL INTERACTION																		
Convenient and secure storage of collective projects in process	3	4	3	2	4	2		2	4	4	3	3	3	2		2	2.93	0.83
Acoustic privacy from other groups	3	3	2	3	4	2	3	3	4	4	3	3	4	4	4	3	3.25	0.68
Autonomy of access to group work area (allows team members to work on projects as mood strikes)	4	4	2	2	3	3	3	1	3	4	2	2	4	3	3	3	2.88	0.89
Presentation area – present acquired knowledge, skills and abilities	4	4	2	3	3	3		2	4	4	3	3	3	3		3	3.14	0.66
Team workstations/shared spaces	3	4	3	3	3	3		2	4	4	4	3	4	3	3	4	3.33	0.62
Faculty collaborative space	4	4	4	4	3	3		1	4	4	3	4	4	2	3	4	3.40	0.91

A building of niches (allows many small groups to claim space and meet in regular locations)	3	4	4	2	2	2		1	4	4	3	3	4	2		4	3.00	1.04
A town square (large area all pass though-promotes casual contact)	4	4	3	3	2	3		1	4	3	3	2	3	3		3	2.93	0.83
Commons areas appropriate for age group	4	4	3	3	2	3	3	2	4	3	3	2	3	3		3	3.00	0.65
Display space and studios for ideas, processes, projects and products (including tack surfaces)	3	4	4	3	3	2	4	2	4	4	4	3	3	3		3	3.27	0.7
Informal learning spaces where students, teachers, and staff can continue learning beyond the confines of the “classroom”	4	4	4	3	3	3	4	2	4	4	3	2	4	3	3	3	3.31	0.7
Spaces to accommodate different size groups	3	4	2	3	3	3	2	2	4	4	2	3	4	3		3	3.00	0.76
Conference spaces	3	4	3	3	3	4		3	4	4	3	3	4	3	3	3	3.33	0.49
Absence of "departments"	4	4	4	2	2	4		1	4	4	2	2	4	2		2	2.93	1.14
Interior windows for visibility of learning process	3	3	3	3	3	2		2	4	4	3	2	3	2	4	2	2.87	0.74
Spaces for design, production, and testing and evaluation, and application of products	3	3	3	2	3	2		2	4	4	2	2	4	2		3	2.79	0.8
DIVERSITY OF ACTIVITIES																		
Music rooms	3	3		2	3	3	2	2	4	4	4	3	3	3		3	3.00	0.68
Science laboratories	3	3	3	3	4	4	4	3	4	4	4	4	3	4		3	3.53	0.52
Physical education facilities	2	3	2	2	4	3		3	3	4	2	4	3	4		3	3.00	0.78
Professional spaces for teachers (including work rooms, lounges, offices, professional library)	3	2	4	3	2	3	2	2	4	4	4	4	4	4	2	3	3.13	0.89

Outdoor learning spaces (natural, man-made)	3	3	4	3	3	2	2	2	4	4	2	4	3	3	3	4	3.06	0.77
Food service areas	2	2	2	3	3	3	3	3	4		3	4	3	4		3	3.00	0.68
SPATIALITY & SCALE																		
Site size	2	2	2	3		2		1	4	3	2	3	2	2	3	2	2.36	0.74
School building size (e.g., square footage, does it allow for school within a school or learning “houses” if large school?)	3	3	4	3		3	2	1	4	4	3	4	3	3	4	3	3.13	0.83
Classroom size (square footage)	3	3	3	3		3	4	3	4	4	3	4	2	4	4	2	3.27	0.7
Classroom shape	2	3	4	4	3	2	3	3	4	4	3	2	4	4	3	3	3.19	0.75
Relative scale of building elements	2	3	3	3	2	2	3	2	4	4		2	3	4	3	2	2.80	0.77
OWNERSHIP & CONTROL																		
Individual workspace (student “owned,” allows a quiet home base, control of the modes of work)	3	4	4	3	3	3	3	2	4	4	2	3	3	3		4	3.20	0.68
Lockable, personalized storage	2	3	4	3	3	3	2	3	4	4	2	3	3	4		4	3.13	0.74
Student accessible files (students create and maintain an individual learning plan, portfolio of learning evidence)	4	4	4	2	3	4	2	2	4	4	2	3	3	2		4	3.13	0.92
Spaces for students to personalize	3	4	4	2	2	3	4	2	4	4	2	3	3			4	3.14	0.86
Multiple access points and time availability to food and beverages	2	2	3	2	3	2		1	4	4	2	3	3	3		2	2.57	0.85
Control over interior thermal, visual and acoustical conditions	2	3	3	3	3	4	3	4	4	4	3	3	4	2	4	4	3.31	0.7
COMFORT, HEALTH & SAFETY																		
ACOUSTICAL COMFORT																		

Appendix I (cont’d).

Interior noise (e.g., ambient, classroom)	3	4	3	3	4	4	4	4	4	4	4	4	3	4	4	3	3.69	0.48
External noise (e.g., aircraft, highway)	3	4	3	3	4	4	4	4	4	4	4	4	3	3	4	3	3.63	0.5
VISUAL COMFORT																		
Natural lighting (e.g., windows, clerestories, skylights)	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3.88	0.34
Electric lighting (overhead, task)	3	4	3	3	4	4	4	4	4	4	3	4	3	4	3	3	3.56	0.51
Views to the outside	2	4	3	3	2	4	3	4	4	4	4	4	4	4	3	4	3.50	0.73
Contrast between print and paper	3	3	3	3		3	4	4	4	4		3	4	4		3	3.46	0.52
THERMAL COMFORT																		
Air-conditioning (e.g., presence, type)	3	3	3	3	4	4	3	4	4	4	4	4	4	3	4	3	3.56	0.51
Heating	3	3	3	3	4	4	3	4	4	4	4	4	4	3	4	3	3.56	0.51
Individual control over thermal conditions (e.g., ventilation, temperature)	2	4	4	3	4	4	2	4	4	4	4	4	3	2	4	4	3.50	0.82
INDOOR AIR QUALITY																		
Adequate ventilation	3	3	4	4	4	4	3	4	4	4	3	4	3	4	4	4	3.69	0.48
Presence or absence of pollutants indoors (e.g., mold, VOCs)	3	3	4	4	4	4	4	4	4	4	3	4	4	4	4	4	3.81	0.4
Cleanliness	2	4	3	3	3	4	4	4	4	4	4	3	3	3		4	3.47	0.64
SAFETY & SECURITY																		
Site lines within building	3	2	3	4	4	4		2	4	4	1	3	3	3		2	3.00	0.96
Telephones in classroom	2	4	2	4	3	4		4	4	4	1	4	4	3		2	3.21	1.05
Child's perceived safety	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3.94	0.25

Perceived cleanliness (may be affected by condition of student toilets, etc.)	3	4	3	3	4	4	3	4	4	4	4	4	3	3	4	3	3.56	0.51
AESTHETICS & APPEARANCE																		
VISIBLE CONDITIONS																		
Perceived quality of classroom condition	3	4	3	3	4	4	4	3	4	4	4	4	3	4	4	3	3.63	0.5
Appearance of walls (e.g., deteriorating plaster, water stains, frequency of painting)	3	4	3	3	4	4	4	4	4	4	4	3	3	4	4	3	3.63	0.5
Age of the school building	1	1	2	3	1	3	2	4	3	4	4	3	3	2	4	2	2.63	1.09
Building improvements/modernization	2	3	3	3	4	3	3	4	4	4	4	4	4	2	4	3	3.38	0.72
SENSORY STIMULATION																		
Floor coverings	2	3	3	3	3	3	3	4	4	4	3	3	4	3	3	2	3.13	0.62
Wall coverings or treatments	2	2	2	2	2	2	3	3	4	4	3	1	4	3	3	2	2.63	0.89
Colors	2	2	2	2	2	2	2	4	4	4	3	2	3	3	3	2	2.63	0.81
BUILDING LEGIBILITY																		
Integration of culture into design	3	3	4	3	1	4	3	2	4	4	3	3	3	2	3	2	2.94	0.85
Integration of student work into design	3	4	4	3	1	3	4	2	4	4	3	3	2	2	3		3.00	0.93
RESOURCES																		
COMMUNITY RESOURCES																		
Visitors easily accommodated (parking, access, work areas)	3	3	2	2	4	2	1	2	4	4	1	4	2	2		2	2.53	1.06
Location in residential, urban/commercial or industrial area	4	2	1	3	4	2	2	1	4	4	2	3	3	3	3	3	2.75	1

Community, business, volunteer, and parent space within the facilities	4	3	3	3	3	4	2	1	4	4	1	2	3	3		2	2.80	1.01
Learning spaces in the community - shared spaces such as libraries, physical fitness centers, museums,	4	3	3	3	3	4		1	4	4	2	4	4	2	3	2	3.07	0.96
Small business incubator space	3	2	2	1	1	2	3	1	4	4	1	2	3	1		1	2.07	1.1
TECHNOLOGY RESOURCES																		
Internet access	2	4	2	3	4	4	3	4	4	4	4	4	4	4	4	3	3.56	0.73
Autonomous access to computer and library materials	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	3	3.81	0.4
Phone, copiers, fax – especially important if students are working with business and community partners in producing "real world" solutions	3	4	3	3	4	4	3	4	4	4	3	2	4	3		2	3.33	0.72
HUMAN RESOURCES WITHIN SCHOOL																		
Access to intellectual advice (implies faculty offices with ability to house one or a handful of visiting students)	4	4	3	3	3	3	3		4	4	2	3	2	3		2	3.07	0.73
Counselors among students (college and career advice available without special trip through unwelcoming administrative territory)	4	4	4	3	3	4	4		4	4	3	4	3	3		2	3.50	0.65
Adult-student spatial integration that keeps teachers from retreating into adult "ghettos" where they never have to contact kids, and into which kids are not welcomed	4	4	3	3	3	4	3		4	4	3	3	4	2		2	3.29	0.73

SECTION II																		
RELATIVE RATINGS OF FUNCTIONALITY ELEMENTS																		
CROWDENESS OR SPACIOUSNESS	10	10	10	15		12	40	36	10	18	40	18	10	15	25	10	18.60	11.3
COLLABORATION & SOCIAL INTERACTION	20	25	25	15		14	5	9	15	18	5	10	15	15	15	19	15.00	6.05
FLEXIBILITY	15	15	5	15		16	10	9	25	18	5	15	12	15	25	10	14.00	5.92
PRIVACY	10	15	5	10		11	10	18	5	18	15	12	13	15		14	12.21	4.06
OWNERSHIP & CONTROL	15	10	20	10		10	15	9	10	5	5	13	15	15	10	19	12.07	4.45
SPATIALITY & SCALE	10	5	15	20		16	5	9	10	5	10	10	15	10	10	14	10.93	4.35
DIVERSITY OF ACTIVITIES	10	15	15	8		10	5	9	15	9	10	12	15	10	10	10	10.87	2.97
WAYFINDING/MOV'T THROUGH BLDG	10	5	5	7		11	10		10	9	10	10	5	5	5	5	7.64	2.53
TOTAL	100	100	100	100	0	100	100	99	100	100	100	100	100	100	100	101	#####	
RELATIVE RATINGS OF COMFORT, HEALTH & SAFETY ELEMENTS																		
ACOUSTICAL COMFORT	20	25	10	15		19	30	24	15	20	30	25	20	20	30	25	21.87	5.91
VISUAL COMFORT	25	20	40	15		19	30	10	15	20	20	20	20	20	30	15	21.27	7.45
THERMAL COMFORT	15	15	10	20		19	20	48	15	20	30	20	20	20	20	25	21.13	8.72
SAFETY & SECURITY	20	20	20	30		24	10	5	25	20	15	20	20	20	10	10	17.93	6.69
INDOOR AIR QUALITY	20	20	20	20		19	10	14	30	20	5	15	20	20	10	25	17.87	6.23
TOTAL	100	100	100	100	0	100	100	101	100	100	100	100	100	100	100	100	#####	

RELATIVE RATINGS OF AESTHETICS & APPEARANCE ELEMENTS																		
VISIBLE CONDITIONS	30	60	20	45		35	40	33	30		65	35	40	50		30	39.46	12.7
SENSORY STIMULATION	35	20	30	35		30	40	67	40		20	40	40	35		50	37.08	12.2
BUILDING LEGIBILITY	35	20	50	20		35	20		30		15	25	20	15		20	25.42	10.3
TOTAL	100	100	100	100	0	100	100	100	100	0	100	100	100	100	0	100	#####	
RELATIVE RATINGS OF RESOURCES ELEMENTS																		
HUMAN RESOURCES WITHIN SCHOOL	45	40	50	40		30	60	25	30		30	70	33	25	40	30	39.14	13.3
TECHNOLOGY RESOURCES	20	40	20	35		45	30	63	30		40	15	33	50	30	50	35.79	13.3
COMMUNITY RESOURCES	35	20	30	25		25	10	13	40		30	15	33	25	30	20	25.07	8.7
TOTAL	100	100	100	100	0	100	100	101	100	0	100	100	99	100	100	100	#####	

NOTE: Some values in the previous sections were normalized since the total for each section did not add up to 100 points.

NOTE: Changed respondent's 1 for circulation spaces to "no data" because the person commented that he/she didn't know and couldn't uncheck the box

Appendix I (cont'd).

APPENDIX J

QUESTIONNAIRE 2 COMMENTS BY RESPONDANTS

PART I: RATING IMPORTANCE OF ITEMS

FUNCTIONALITY

Wayfinding/Movement Through Building

I'm not sure why "grade configuration" is linked to movement through building as a category.

Much depends on the curriculum delivery model and teacher interaction.

Color, light, lighting, floor plan are all important to wayfinding.

What do you mean by grade configuration? Obviously there is great variety and sometimes the grade configuration might matter more than in other cases. Similarly, what do you mean by relationship of spaces within building?

Good architectural design lends to wayfinding without as much need for signage or posting of rules. Grade configuration can be done in many good ways--cross-disciplinary; cross-grade; same grade.

I just want to confirm that I am rating these as my perception of how they refer to relationship to educational achievement. Second comment - I am not sure what is meant by grade configuration, but assume it means that one section of the building would have one grade, and another, another grade and so on? - at least, that is how I am interpreting this one.

Grade as in slope of a surface or academic grade?

Mixed age groupings can be effective

Crowdedness or Spaciousness

Circulation spaces are more than transition... social interaction as well and opportunities to "peek" at other learning interactions.

Messy spaces, coats, boots on floor and chaotic display systems.

I want to comment on the choices overall, but it strikes me here especially - I am not aware of research on the impact of circulation spaces - that is, I don't know. So I initially hit "not important" but what I meant to say was "not clear" or "I don't know" - I can't uncheck the box, however.

crowding is affected by many factors beyond density

Flexibility

The meaning of "site" and "school building" a bit vague... may be helpful to have examples.

Possibly the most important design element to consider and provide to enhance sustainability of the building and programs

How can any of this NOT be important?

School building is somewhat ambiguous - I would argue the physical condition of the building matters, but not sure about the ability to add-on or adapt to reuse. That is a matter for consideration of architects, I imagine, but I would think the student taking a class doesn't think about that at all - that that is the level at which are measuring - the impact on the individual student. This goes for some of the other points - we are talking about aspects that affect students *through other means*, such as access to electronic equipment. Having good technology helps the students (that is the hypothesis, anyway). Having outlets doesn't help in the slightest. Having outlets that allow a teacher to use the technology is the link. But when we do these analyses, we need to be careful of understanding the links. That is why I am a little hesitant with some of my rankings. If I rank outlets high, is it really that I am ranking the idea that this means the students get the stuff that uses the outlets? Do you see my quandary?

Location of site can be important convenient to a variety of community resources.

Privacy

For both faculty and students.

Again, depends on the "culture" of the school and curriculum delivery model.

Too often, this is overlooked. One of my participants suggested that we all need places to get away from the "buzz" of the technology. Reflection is one of the most powerful learning tools and we most often do not encourage or provide spaces for this activity. Students have told us private space is very important.

For teachers.

Collaboration and Social Interaction

This is a really interesting set of spatial criteria; I'm glad to see you addressing that. Typo in third item... better word than "mood" more like opportunity... as to "departments" vs "collaboration," these have to be built from within as well as from leadership. Last item again depends on delivery model.

In the last question, what do you mean by "products"?

All of these are necessary to prepare learners for next steps in life.
No replication of classrooms as classrooms could have content focus and students moving through spaces even at elementary level, such as greenhouse, dance studio,
Just noting my own ignorance - I am not sure of academic research on many of these specific issues, but this is my perception of the importance of these.

This is one of the most important factors. Diverse learning settings that flow between and provide a variety of activity settings.

Diversity of Activities

The school may be part of a network where these facilities may be "shared" among other schools or with the community.

Let's not forget community volunteers and business partners--they need space to call their own, too.

Don't forget the arts and architecture places to build models, etc.

Location of food and water, as well as out door settings is very important to the integration of learning activities into a whole learning experience.

Spatiality and Scale

"School within a school" seems not only to have to do with size, but also with a sense of spatial autonomy; that there are real identifiable boundaries that all of the occupants can recognize.

Another "depends"... these items are more designer than teacher concerns although still important.

I can't answer the size questions, since it has to be standardized by the size of the school or the class.

Important for adaptability and reuse.

Don't like the word classroom. Do like the words learning environments.

Scale of each learning setting is what is important. Shape of space effects crowding (awareness of others.

Ownership and Control

The last item "control" depends on the scale of the space... the more users, the less ability to have a consensus about control but still important.

All of these support relevant and meaningful learning activities and provides learners opportunities to learn to manage their own learning, needs, and spaces.

Ownership of space is important

COMFORT, HEALTH & SAFETY

Acoustical Comfort

I have found these to be the biggest issues but there are parameters that have to do with "expectations" (i.e., if expected less annoying...).
One only needs to spend time at Highline Community College south of the SEATAC airport in Washington to understand the importance of this feature. Interior acoustics are important as a means for staying focused and for alleviating stress.

Visual Comfort

Glare is an underrated (and less understood) albeit an important issue but one that has more to do then just contrast.

I don't get this one: Contrast between print and paper.
Addresses health issues as well as learning issues.

Check research on all this...it affects learning.

There is good research on day lighting, full spectrum artificial lighting, and views to the outside.

Thermal Comfort

Regional issues as well.

Use of natural ventilation is something to move toward. Again, if a person is comfortable, they are better able to learn. Having the HVAC system be a learning tool for math and science is great.

Comfort counts

Indoor Air Quality

Perception a biggie here.

Healthy people are better able to learn.

Safety & Security

First item depends on the scale.

Telephones in the classroom also support project-based learning when the projects are real and community-based. These projects require student access to phones. This then becomes a back-up security measure without being obtrusive.

Must be perceived as a safe place

AESTHETICS & APPEARANCE

Visible Conditions

Good questions.

The age is not as important as the building's upkeep. If learners are proud of their facilities, vandalism decreases. The facility should engender trust and responsibility.

Research on aesthetics and Kozal

Sensory Stimulation

Some studies indicate "over stimulation" as a problem.

As you know, there are big debates about floor coverings and the extent to which rugs and carpets produce indoor air pollution.

Learning spaces should not be perceived as areas of punishment. They should demonstrate the importance of human needs.

Cool and natural colors usually best- calming, lowers blood pressure. Floor is experienced multi sensorially.

Building Legibility

Allowing cultural influence on the building to change over time... priceless :o)

Absolutely. Why are the learners there if we do not honor and showcase them and their work?

Now that I see this again, I'm really not sure that "building legibility" is the appropriate label for integration of culture and student work into the design. Maybe that's "personalization' or "relevance" or something else...

RESOURCES

Community Resources

2nd item a bit vague.

Invite the community in and take the learning out in the community--connections and relationships is what it is all about.

Integration of learning into the community using real issues and adults who are involved with them engages the learner- makes learning relevant

Technology Resources (students and staff)

Good questions but some issues with copyright and porn access.

Give the learners and teachers the tools they need to succeed and excel.

Human Resources Within the School

This is "sacred" territory for some schools... good questions to bring up the issues.

These have nothing to do with the building.

Absolutely--break down the barriers.

Appendix J (cont'd).

PART II: RELATIVE RATINGS AMONG ELEMENTS OF EACH FEATURE

FUNCTIONALITY

This is a tough one. I'm really not sure how to quantify these, since the categories contain so many individual variables. What do you get from this section that is different information than the individual item rankings we've previously done?
It would be nice to have an automatic sum so you could see the total as you add.

All topics should be equal.

COMFORT, HEATLH & SAFETY

Part of the difficulty with these is that there is some threshold quality which one can't pass below, or the building becomes intolerable. But once one reaches those thresholds, then their relative value may change. Are we rating the relative value of meeting the baselines, or of some enhanced condition? There's a difference between doing something "not badly" and actually doing it well, and they might be ranked differently on that basis. [AFTER THIS COMMENT WAS RECEIVED, SURVEY INSTRUCTIONS WERE MODIFIED TO READ, "Rate them based on how important it is that they be done well (better than average)"; ONLY 2 INDIVIDUALS DID NOT HAVE THESE INSTRUCTIONS].

I cannot rate these - they are all equally important...distribute 100 equally for me.

AESTHETICS & APPEARANCE

Now that I see this again, I'm really not sure that "building legibility" is the appropriate label for integration of culture and student work into the design. Maybe that's "personalization' or "relevance" or something else.

RESOURCES

Here again, I think that my ranking of technology as only 20% is the same thing I did on earlier pages by saying that it wasn't very important. How is this new information?

NOTES

Totals did not always add up to 100. This software does not provide the ability to use an auto-adder.

APPENDIX K

FRAMEWORK OF PHYSICAL VARIABLES PLAUSIBLY RELATED TO EDUCATIONAL OUTCOMES: VERSION 2

NOTE: When physical spaces are listed below, “the provision of …” is implied but not stated. For example, Presentation Area below means, “the provision of a presentation area.”

FUNCTIONALITY

Building Legibility

Signage
Grade configuration
Relationship of spaces within building
Color
Lighting/light
Floor plan

Crowdedness or spaciousness

Overcrowded conditions (possibly determined by % capacity for school achieved, square foot per child in the classroom)
Circulation spaces and patterns that do not force hundreds or thousands of students into narrow, long spaces
Space to keep items (e.g., coats, boots) from lying around and appearing “messy”

Flexibility

Site – the grounds and its components that surround a school building or set of buildings (flexibility may refer to having a site that is large enough to accommodate changing needs or may refer to having flexible types of spaces on site such as an outdoor learning area that also includes tables and chairs where students and teachers may eat lunch)
School building or buildings (flexibility may refer to the ability to add on or renovate to meet changing needs)
Learning environment (e.g., walls, equipment)
Seating (comfortable and flexible, allows different seating configurations)
Work surfaces (adequate surfaces of different heights, sizes and shapes to support work)
Fluidity of seating and work surfaces to meet shifting and immediate needs
Adequate and well-placed electric outlets so that teachers can better utilize technology

Privacy

Spaces for quiet reflection (however created – furnishings, walls, doors, etc.) for both students and faculty
Collaboration and social interaction
Convenient and secure storage of collective projects in process
Acoustic privacy from other groups
Autonomy of access to group work area (allows team members to work on projects as mood and/or opportunity strikes)
Presentation area – present acquired knowledge, skills and abilities
Team workstations/shared spaces
Faculty collaborative space
A building of niches (allows many small groups to claim space and meet in regular locations)
A town square (large area all pass though-promotes casual contact)
Commons areas appropriate for age group
Display space and studios for ideas, processes, projects and products (including tack surfaces)
Informal learning spaces where students, teachers, and staff can continue learning beyond the confines of the "classroom"
Spaces to accommodate different size groups
Conference spaces
Absence of "departments"
Interior windows for visibility of learning process
Spaces for design, production, and testing and evaluation, and application of **products**
Circulation spaces that promote social interaction and provide opportunities to view other learning environments

Diversity of Activities

Music rooms
Science laboratories
Physical education facilities
Professional spaces for teachers (including work rooms, lounges, offices, professional library)
Outdoor learning spaces (natural, man-made) - availability and their location
Food service areas – availability and their location
Spaces for building models, art work, etc.

Spatiality and Scale

Site size
School building size (e.g., square footage, does it allow for school within a school or learning "houses" with clear, identifiable boundaries if large school?)
Learning environment size (square footage)
Learning environment shape

Relative scale of building elements

Ownership and Control

Individual workspace (student "owned," allows a quiet home base, control of the modes of work)
Lockable, personalized storage
Student accessible files (students create and maintain an individual learning plan, portfolio of learning evidence)
Spaces for students to personalize
Multiple access points and time availability to food and beverages
Control over interior thermal, visual and acoustical conditions
Integration of culture into design
Integration of student work into design

COMFORT, HEALTH & SAFETY

Acoustical comfort

Interior noise (e.g., ambient, inside the learning environment)
External noise (e.g., aircraft, highway)

Visual comfort

Natural lighting (e.g., windows, clerestories, skylights)
Electric lighting (overhead, task)
Views to the outside
Visual conditions that affect occupants' ability to read and see comfortably such as glare, contrast between print and paper, etc.

Thermal comfort

Air-conditioning (e.g., presence, type)
Heating
Individual control over thermal conditions (e.g., ventilation, temperature)

Indoor air quality (real and perceived)

Adequate ventilation
Presence or absence of pollutants indoors (e.g., mold, VOCs)
Cleanliness

Safety and security (real and perceived)

Site lines within building

Child's perceived safety
Telephones in classroom (more important as a resource for project-based learning when projects are community based, however, serve as a back-up security device)

AESTHETICS & APPEARANCE

Visible conditions

Perceived cleanliness (may be affected by condition of student toilets, etc.)
Perceived quality of learning environment conditions
Appearance of walls (e.g., deteriorating plaster, water stains, frequency of painting)
Age of the school building
Building improvements/modernization

Sensory stimulation (appropriate, but not excessive)

Floor coverings
Wall coverings or treatments
Colors
Neat rather than chaotic display systems

RESOURCES

Community Resources

Visitors easily accommodated (parking, access, work areas)
Location that is convenience to community resources
Community, business, volunteer, and parent space within the facilities
Learning spaces in the community - shared spaces such as libraries, physical fitness centers, museums,
Small business incubator space

Technology Resources (students and staff)

Internet access
Autonomous access to computer and library materials
Accessible phone, copiers, fax – especially important if students are working with business and community partners in producing "real world" solutions
The use of the school building as a teaching tool

Human Resources (within the school)

Access to intellectual advice (implies faculty offices with ability to house one or a handful of visiting students)

Counselors among students (college and career advice available without special trip through unwelcoming administrative territory)

Adult-student spatial integration that keeps teachers from retreating into adult "ghettos" where they never have to contact kids, and into which kids are not welcomed

SURVEY 3: *Suppose this group of Delphi panel members has been given a HUGE sum of money to investigate links between school facilities and measures of student, school, or school district success. It is our job to identify research priorities. In fact, we* ***are*** *developing a research agenda for this field. Survey 3 gives you the opportunity to identify those relationships that should be studied first. The following list of physical factors are those you identified as plausibly related to educational outcomes (revised based on your responses to Survey 2). The physical factor that received the highest group rating on Survey 2 is listed at the top, and the one receiving the lowest rating is near the bottom. The last seven items have been added to the list of physical factors per your Survey 2 responses, and therefore have not been rated.*					
Please complete and return by May 30; Please name your file lastnameS3.xls	**FIRST: Rate your level of familiarity with each item:** **1** Not experienced enough to suggest links to educational outcomes **2** **3** Familiar with this area at a general level **4** **5** Active researcher in this area			**SECOND: For ONLY those you rate yourself a 3-5, list the Measures of Success (see tab below) that may be linked to those items. Begin with the physical factors that were rated the highest among the group. Do not be concerned that the Measures of Success are not all dependent variables or that these measures are on different levels (e.g., reading skills vs. student performance). These were derived from the literature and educators.**	**THIRD: Develop hypotheses for how the physical factors are related to the measures of success. Please include any mediator or moderator variables that you believe should be studied (see Definitions tab). Complete only for items you rate yourself a 3-5.**
Pleas focus your attention on the items in yellow (those rated a 3.2 or higher). However, you may also comment on lower rated items, if desired.	**SELF RATING**	**AVG RATING (1-4)**	**STD DEV**	**MEASURES OF SUCCESS Plausibly Related to This Item (Select from Measures of Success tab)**	**HYPOTHESIS(ES)**

Item	**Self Rating**	**Avg Rating (1-4)**	**Std Dev**		
Telephones in classroom (more important as a resource for project-based learning when projects are community based, however, serve as a back-up security device)	*Example*: 3	3.94	0.25		*Example:* telephones in the classroom, when used for community-based projects, prepare students for the "real world," giving them skills that will please employers
Overcrowded conditions (possibly determined by % capacity for school achieved, square foot per child in the classroom)		3.88	0.34		
Natural lighting (e.g., windows, clerestories, skylights)		3.88	0.34		
Presence or absence of pollutants indoors (e.g., mold, VOCs)		3.81	0.40		
Autonomous access to computer and library materials		3.81	0.40		
Interior noise (e.g., ambient, inside the learning environment)		3.69	0.48		
Adequate ventilation		3.69	0.48		
External noise (e.g., aircraft, highway)		3.63	0.50		
Perceived quality of learning environment conditions		3.63	0.50		

Item	**Self Rating**	**Avg Rating (1-4)**	**Std Dev**		
Appearance of walls (e.g., deteriorating plaster, water stains, frequency of painting)		3.63	0.50		
Electric lighting (overhead, task)		3.56	0.51		
Air-conditioning (e.g., presence, type)		3.56	0.51		
Heating		3.56	0.51		
Perceived cleanliness (may be affected by condition of student toilets, etc.)		3.56	0.51		
Internet access		3.56	0.73		
Science laboratories		3.53	0.52		
Views to the outside		3.50	0.73		
Individual control over thermal conditions (e.g., ventilation, temperature)		3.50	0.82		
Counselors among students (college and career advice available without special trip through unwelcoming administrative territory)		3.50	0.65		
Cleanliness		3.47	0.64		
Visual conditions that affect occupants' ability to read and see comfortably such as glare, contrast between print and paper,		3.46	0.52		

Appendix L (cont'd).

Item	Self Rating	Avg Rating (1-4)	Std Dev		
etc.					
Seating (comfortable and flexible, allows different seating configurations)		3.44	0.51		
Faculty collaborative space		3.40	0.91		
Learning environment (e.g., walls, equipment)		3.38	0.72		
Building improvements/modernization		3.38	0.72		
Team workstations/shared spaces		3.33	0.62		
Conference spaces		3.33	0.49		
Accessible phone, copiers, fax – especially important if students are working with business and community partners in producing "real world" solutions		3.33	0.72		
Fluidity of seating and work surfaces to meet shifting and immediate needs		3.31	0.87		
Spaces for quiet reflection (however created – furnishings, walls, doors, etc.) for both students and faculty		3.31	0.87		

Appendix L (cont'd).

Item	**Self Rating**	**Avg Rating (1-4)**	**Std Dev**		
Informal learning spaces where students, teachers, and staff can continue learning beyond the confines of the “classroom”		3.31	0.70		
Control over interior thermal, visual and acoustical conditions		3.31	0.70		
Adult-student spatial integration that keeps teachers from retreating into adult “ghettos” where they never have to contact kids, and into which kids are not welcomed		3.29	0.73		
Display space and studios for ideas, processes, projects and products (including tack surfaces)		3.27	0.70		
Learning environment size (square footage)		3.27	0.70		
Acoustic privacy from other groups		3.25	0.68		
Child's perceived safety		3.21	1.05		
Individual workspace (student “owned,” allows a quiet home base, control of the modes of work)		3.20	0.68		

Appendix L (cont'd).

Relationship of spaces within building		3.19	0.66		
Work surfaces (adequate surfaces of different heights, sizes and shapes to support work)		3.19	0.66		
Learning environment shape		3.19	0.75		
Presentation area – present acquired knowledge, skills and abilities		3.14	0.66		
Spaces for students to personalize		3.14	0.86		
School building size (e.g., square footage, does it allow for school within a school or learning "houses" with clear, identifiable boundaries if large school?)		3.13	0.83		
Lockable, personalized storage		3.13	0.74		
Student accessible files (students create and maintain an individual learning plan, portfolio of learning evidence)		3.13	0.92		
Professional spaces for teachers (including work rooms, lounges, offices, professional library)		3.13	0.89		
Floor coverings		3.13	0.62		

Appendix L (cont'd).

Access to intellectual advice (implies faculty offices with ability to house one or a handful of visiting students)		3.07	0.73		
Learning spaces in the community - shared spaces such as libraries, physical fitness centers, museums,		3.07	0.96		
Outdoor learning spaces (natural, man-made) - availability and their location		3.06	0.77		
School building or buildings (flexibility may refer to the ability to add on or renovate to meet changing needs)		3.00	0.89		
A building of niches (allows many small groups to claim space and meet in regular locations)		3.00	1.04		
Commons areas appropriate for age group		3.00	0.65		
Spaces to accommodate different size groups		3.00	0.76		
Music rooms		3.00	0.68		
Physical education facilities		3.00	0.78		
Food service areas – availability and their location		3.00	0.68		
Integration of student work into design		3.00	0.93		

Site lines within building		3.00	0.96		
Adequate and well-placed electric outlets so that teachers can better utilize technology		2.94	0.93		
Integration of culture into design		2.94	0.85		
Circulation spaces and patterns that do not force hundreds or thousands of students into narrow, long spaces		2.93	0.88		
Convenient and secure storage of collective projects in process		2.93	0.83		
A town square (large area all pass though-promotes casual contact)		2.93	0.83		
Absence of "departments"		2.93	1.14		
Autonomy of access to group work area (allows team members to work on projects as mood and/or opportunity strikes)		2.88	0.89		
Interior windows for visibility of learning process		2.87	0.74		
Relative scale of building elements		2.80	0.77		
Community, business, volunteer, and parent space within the facilities		2.80	1.01		

Spaces for design, production, testing and evaluation, and application of products (student developed – even products to sell)		2.79	0.80		
Location that is convenience to community resources		2.75	1.00		
Site – the grounds and its components that surround a school building or set of buildings (flexibility may refer to having a site that is large enough to accommodate changing needs or may refer to having flexible types of spaces on site such as an outdoor learning area with tables and chairs that can be used during lunch)		2.73	0.88		
Age of the school building		2.63	1.09		
Wall coverings or treatments		2.63	0.89		
Colors		2.63	0.81		
Multiple access points and time availability to food and beverages		2.57	0.85		
Visitors easily accommodated (parking, access, work areas)		2.53	1.06		
Signage		2.47	0.99		
Site size		2.36	0.74		

Grade configuration (refers to the manner in which grade levels are organized into a single school, e.g. K-3, K-5, K-12) Districts are increasingly willing to consider non-traditional grade configurations, such as K-8 or K-12.		2.33	1.11		
Small business incubator space		2.07	1.10		
		NR = not rated			
Color (with respect to building legibililty/wayfinding)		NR	NR		
Lighting (with respect to building legibililty/wayfinding)		NR	NR		
Floor plan/ the sequencing of spaces (with respect to building legibililty/wayfinding)		NR	NR		
Space to keep items (e.g., coats, boots) from lying around and appearing "messy"		NR	NR		
Circulation spaces that promote social interaction and provide opportunities to view other learning environments		NR	NR		
Spaces for building models, art work, etc.		NR	NR		
The use of the school building as a teaching tool		NR	NR		

APPENDIX M

RESEARCHER-DEVELOPED HYPOTHESES

Hypotheses Sorted by Physical Factors

Combinations of Physical Factors or Otherwise NR
A combination of individual student workspace, spaces for students to personalize and lockable personal storage will create a sense of ownership in students that may lead to better attitudes toward school and motivation to learn that will positively influence their performance, greater student attendance and overall success in school, socially and academically.
Circulation spaces designed with niches, benches, seating areas, natural light will provide opportunities for students and teachers to informally interact as they move through the building that may support an improved social climate and culture and build social capital within the school that will overtime lead to the academic growth of students, greater attendance by students, teacher/administrative retention, school connectedness, affective performance, as well as create a student friendly environment.
Learners have an increased desire to learn when they have access to appropriate technology, equipment, and information to discover and create new knowledge
Increasing learner to learner, learner to teacher, and teacher to teacher interactions provides a greater depth of knowledge acquisition and increased ability to resolve conflicts, problem solve, and work in teams.
Providing learning environments that closely resemble "next-steps-in-life" environments better prepares learners to be successful throughout life.
When psychological and physiological needs (natural light, comfortable-flexible furnishings, sense of connection or belonging) are met the learner is better prepared to contribute to and absorb new information.
Well-designed learning environments that support and enhance learning increase retention and satisfaction among students, teachers, and staff.
Community involvement and project-based learning prepares learners for work, family, community, and personal life.
A less formal structure of schooling (I.e. social interaction, overviews) may provide greater opportunities for student academic achievement (Re: Circulation Spaces that Promote Social Interaction and Provide Opportunities to View Other Learning Environments - NR)
Telephones in Classroom (3.94)
I think ease of parental contact is important, as well as efficiency in doing other school related business. Use by students as a resource may also be important. Cell phones should not be overlooked as a teacher efficiency device
Overcrowded Conditions (3.88)
Students in over-utilized buildings will score lower on measures of student performance and have lower attendance rates than students in properly utilized buildings.
A learning space that is too small for the number of occupants (I.e. feels "overcrowded) will result in adverse behavior for all involved acting as a mediating variable affecting a host of academic and teacher job satisfaction related measures.
Overcrowding leads to poorer performance
Overcrowded conditions, especially as measured by classroom spatial density may create physiological and psychological stress in students decreasing their mental concentration and ability to focus on tasks (moderated by quality and quantity of student-teacher interaction) and may over time affect their achievement as measured by reading readiness, mathematics scores.

Appendix M (cont'd).

Reduction of class size will result in increased attentiveness and consequently reduce absenteeism
(Re: overcrowded conditions) ON-task behavior is a key indicator of learning, and discipline time detracts from this. Also one on one teaching is important for kids who do not get one on one at home
Daylighting (3.88)
Natural illumination of general learning spaces (with controls such as blinds or screens) help improve human behavior thereby mediating academic and teacher job satisfaction measures.
Daylighting has been shown (Heschong-Mahone study) to have a significant imp act on elementary level student performance. It can be assumed that these same benefits persist in middle and high school environments that have high levels of daylight in the classrooms.
(Re: daylighting) Lack of light affects moods as well as effort on task
Daylight in the classroom can create a pleasant environment and improve student performance
Students in daylit classrooms will score higher in achievement tests than students in classrooms without natural daylight. Daylit classrooms will experience lower absentee rates than non-daylit classrooms. Teachers in daylit classrooms will express higher job satisfaction than teachers in non-daylit classrooms. Daylit classrooms will experience fewer student suspensions than non-daylit classrooms.
Students in buildings that have daylighting features will perform higher on measures of achievement than will students in buildings that do not have such features.
Indoor Air Quality/ Presence or Absence of Pollutants (3.81)
Perceived indoor pollution within a school building will have adverse affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures.
Poor indoor air quality, especially ventilation, may negatively impact student health leading to a decreased focus on learning tasks while in school, and lower attendance in school due to sickness that may over time affect their achievement (reading readiness and mathematics).
Classrooms with poor IAQ will have higher asthma rates than classrooms with good IAQ. Classrooms with poor IAQ will have higher student and teacher absentee rates than classrooms with good IAQ. Test scores of students in classrooms with IAQ problems will be lower than those of students in classrooms with good IAQ.
Student test scores in elementary schools correlate positively with indoor air quality in the classroom.
Adequate Ventilation (3.69)
Adequate ventilation of general learning spaces (with controls such as blinds or screens) help improve human behavior thereby mediating academic and teacher job satisfaction measures.
Ventilation systems that provide 100% outside air positively impact student health and reduce abseenteeism due to illness.
Internal Noise (3.69)
Excessive internal noise generated and reflected within a learning space will adversely affect (moderate) student performance and diminish teacher job satisfaction.
Interior noise negatively impacts a student's ability to learn. This is particularly true in the early grades (elementary and middle school) and in students with hearing impairments and/or for whom English is a second language
Interior background noise may produce intelligibility of the teacher's voice as well as produce fatigue in students that may affect their mental concentration and ability to focus on tasks and may over time affect their achievement as measured by reading readiness, mathematics scores.
(Re: internal noise and teacher perception/on-task behavior) Some kids very sensitive to noisy environments
Unwanted noise in the classroom can create distractions and become a source of disturbance

Appendix M (cont'd).

In classroom with significant background noise (HVAC system, etc.), students who sit closer to teacher will have higher achievement scores than those who sit far away from the teacher.
Students in buildings that are excessively noisy will perform lower on measures of achievement than students in quiet buildings.
External Noise (3.63)
Excessive external noise transmitted within a learning space will adversely affect (moderate) student performance and diminish teacher job satisfaction.
(Re: external noise) External noise can create distractions and reduce student performance
Schools in close proximity to airports will have higher incidence of learning disabilities.
Quality of Learning Environment Conditions (3.63)
If all members of the school community perceive the school environment to be of high quality, this will improve self-reported satisfaction with the school among teachers, administrators, students, parents and community members.
Students in buildings that are well maintained will perform higher on measures of achievement than will students in poorly maintained buildings.
Perceived poor physical environmental conditions will have adverse affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures.*
Poor physical conditions are associated with poorer academic achievement - for the same reason poor working conditions in business environment are assumed to cause lower worker productivity - people in poor environments do not feel valued, there are distractions, etc.*
Environment affects moods, might encourage improved behavior
Perception of a positively designed physical environmental can have positive affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures.
Cleanliness (3.52)
If all members of the school community perceive the school environment to be clean and well-maintained, this will improve self-reported satisfaction with the school among teachers, administrators, students, parents and community members.
Perceived poor physical environmental conditions will have adverse affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures *
Poor physical conditions are associated with poorer academic achievement - for the same reason poor working conditions in business environment are assumed to cause lower worker productivity - people in poor environments do not feel valued, there are distractions, etc.*
Perceived cleanliness can affect student's pride in their school and reduce vandalism
Schools that are not clean or aesthetically attractive will have higher rates of student discipline problems than schools that are attractive, well-kept and clean.
(Re: cleanliness and on-task behavior/teacher perception) Broken window theory - disorderliness encourages more
School maintenance can influence students' attitudes toward their school and subsequently vandalism

Electric Lighting (3.56)
Adequate electric illumination AND control promotes (mediates) general teacher job satisfaction measures.
Pendant-mounted, indirect lighting fixtures provide a more effective ambient light environment than downlights, resulting in better student performance.
Air Conditioning (3.56)

Adequately mechanical cooled and humidified air (with controls) promotes (mediates) general teacher job satisfaction measures and to some degree moderates student performance.
(Re: AC and on-task behavior/teacher perception) Most of us don't function well in heat
Students in classrooms without air conditioning (at higher temperatures) will experience lower test scores, more behavior problems, higher absentee rates than students in classrooms with AC.*
Students in buildings that have air conditioning in the classrooms will score higher on measures of academic achievement than will students in non aid-conditioned buildings.
Internet Access (3.56)
Freedom of access to academic research material (together with mentored support in use strategies) improves (moderates) academic and professional development in schools.
Science Labs (3.53)
Poor equipment can destroy interest in science
Students in laboratories that have modern furniture and equipment will score higher on science tests than will students who have non-functioning and old furniture and equipment.
Counseling Services (3.50)
If counseling services are located in high-traffic public areas, this will boost student use of such resources in both scheduled and casual ways. Students will feel both welcome within adult structures and also better informed about their academic options and their post-secondary choices. This will boost both student and parent attitudes with regards to the school as a whole.
Close access to counselors among the learning areas promote (mediate) student behavior and consequent academic improvement
Easily accessible career advice will ease anxiety about future options so students are better prepared after graduation
Views to the Outside (3.50)
External views from general learning spaces help improve human behavior thereby mediating academic and teacher job satisfaction measures.
Views to the outside of any given space, especially to daylit outdoors, may decrease eye fatigue thereby allowing a student to maintain mental concentration and focus on the learning task (moderated by classroom management policy of teacher, that is, students being allowed to stare out the window on occasion) and will over time improve their achievement as measured by reading readiness, and mathematics scores.
Views to the outside will affect the classroom atmosphere and subsequently students' performance
Individual Control Over Thermal Conditions (e.g., ventilation, temperature) (3.50)
Adequate controls of mechanical systems promotes (mediates) general teacher job satisfaction measures and to some degree moderates student performance.
(Re: Ind. Control over thermal conditions and student achievement) Students who are hot or cold have a difficult time focusing on classroom work
Student's control over their immediate environment will affect their comfort and consequently their performance
Being able to modify or control the ambient conditions in the learning environment improves learning.
Visual conditions that affect occupants' ability to read and see comfortably such as glare, contrast between print and paper, etc. (3.46)
Adequately designed and controlled illumination of general learning spaces help improve human behavior thereby mediating academic and teacher job satisfaction measures.

Appendix M (cont'd).

Glare and other negative visual conditions can be 'designed out' of a school classroom, resulting in better performance on all visual tasks, including reading and mathematics.
The presence of glare on work surfaces and computer screens may produce eye strain in students that may affect their mental concentration and ability to focus on tasks (and while moderated by their ability to control glare) and may over time affect their achievement as measured by reading readiness, mathematics scores.
Kids can differ greatly on sensitivity to this kind of stuff
Visual discomfort will affect their attentiveness and subsequently student performance
Students in buildings that have good lighting will perform higher on measures of achievement than will students in classrooms that have poor lighting.
Furnishings/Seating (3.44)
If seating is easily manipulable to suit multiple pedagogic purposes, this will increase the range of classroom experiences that students and teachers can employ. This will increase the range of classroom experiences that students and teachers can employ. The broader possible range of pedagogical strategies will lead to increased student academic growth, and will also reduce off-task behavior stemming either from boredom or from working at cross-purposes to the demands/affordances of a static environment
Adequate, well-designed furniture that may be rearranged for appropriate academic and social activities positively affects (mediates) student behavior and teacher job satisfaction.
Flexible seating allows students to work individually or in groups and engage in more intimate contact with the teacher
The ability for students to modify their environment will affect the variety of experiences and activities and consequently a positive attitude towards education
Faculty Collaborative Space (3.40)
The presence of faculty collaborative space, when combined with a school schedule and culture that makes its use the norm, will have countless benefits. Teachers will be more supported by their peers and administrators, and new teachers will be mentored more authentically, with greater participation in professional development. Teacher satisfaction will rise, and faculty attrition and absences will both be reduced. Because teachers will be able to collaborate over difficulties of specific students, those students will be more productive, have better attitudes, and be socially supported (all increasing parental satisfaction and reducing student transience).
Collaborative workspaces provide an opportunity for positive interaction among teachers helping to build an interactive learning culture that improves overall student academic achievement and teacher job satisfaction.
Collaboration is important
Space for faculty planning allows for teaming and an opportunity for their professional growth
Spaces for Quiet Reflection (3.40)
Might help with discipline and order
Perception of an improved positively designed physical environmental can have positive affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures.
Students in well-maintained buildings of good quality will score higher in achievement tests than students in poor quality buildings. Disciplinary problems will be higher in poorly maintained buildings than in good or excellent school buildings. Poorly maintained buildings will experience higher absentee rates than good or excellent buildings.

Appendix M (cont'd).

Team Workstations/ Shared Spaces (3.33)
The availability for students to work comfortably and productively in teams will increase the range of opportunities for both academic and social growth. Students will be more positive about their school, feel more socially connected, and reduce off-task time through ease of using team-based environments. Faculty and parents will both report increased satisfaction with student learning and with the school environment.
Team workstations encourage group work and prepare students for future collaborative employment
Conference Spaces (3.31)
Close access to private conference rooms among the learning areas promote (mediate) student behavior and consequent academic improvement
Spaces for Quiet Reflection (3.31)
The ability for students and faculty alike to find and take advantage of private, quiet space will improve both satisfaction and performance among both groups. Student social development and general affect will be improved through the ability to self-regulate social interaction, and off-task behavior will be reduced through providing quiet space for individual and reflective work.
Might help with discipline and order
Spaces for quiet reflection will minimize student aggression and hostility
Access to and ownership of quiet, reflective spaces promote (mediate) student behavior and consequent academic improvement
Informal Learning Spaces (3.31)
When teachers and students are encouraged to meet informally, this will improve the sense of connectedness of both groups, and the school will be perceived as strongly student-friendly. Satisfaction with the school will increase among all parties involved (including parents), and student performance will increase through greater access to faculty.
Opportunities for social interaction outside the classroom will have a positive affect on their attitude towards education and academic performance
Control over Thermal, Visual and Acoustical Conditions (3.31)
Adequate controls of building systems promotes (mediates) general teacher job satisfaction measures and to some degree moderates student performance.
A controlled study will indicate higher levels of teacher satisfaction in spaces where rudimentary control over interior thermal, visual and acoustical conditions are provided. Satisfaction does not increase as the level of control increases. The presence or absence of some form of control is the most important factor.
Sensitivity of teachers and kids to different conditions
Ability for students to control the thermal environment will affect their comfort and subsequently academic performance
Students in buildings that have air conditioning in the classrooms will score higher on measures of academic achievement than will students in non aid-conditioned buildings.*
Adult-Student Spatial Integration (3.29)
Integration of all learning spaces into heterogeneous groupings promote (mediate) student and teacher behavior and consequent academic improvement
Display Space and Studios for Ideas, Processes, Projects and Products (3.27)
Display spaces for student (and teacher) work promote (mediate) student and teacher behavior and consequent academic improvement
Display space for student work will enhance their self image and subsequently their academic performance

Appendix M (cont'd).

Learning Environment Size (3.27)
The size of the learning environment will influence the seating arrangement and the way that teachers move about the classroom to interact with students
Acoustical Privacy From Other Groups (3.25)
Lack of acoustical privacy within a learning space will adversely affect (moderate) student performance and diminish teacher job satisfaction.
Relationship of Spaces Within Building (3.19)
Spatial organization will affect the amount of social contacts in the school expanding learning opportunities outside of the classroom
Shape of Learning Environment (3.19)
The shape of the learning environment can influence the organization of seating that afford opportunities for group and individual work to occur simultaneously
Spaces for Students to Personalize (3.14)
The ability for students to personalize their environment will affect their self image and minimize vandalism
School Building Size (3.13)
The physical school size affects the possibilities for teacher-student-community interaction and consequent resulting cohesion or friction that may affect student academic progress.
Professional Spaces for Teachers (3.13)
Professional spaces for teachers that include workrooms and especially private offices, will create a sense of ownership in teachers that may lead to better attitudes toward their workplace and motivate them to improve their teaching practice that may lead to better teacher retention, lower teacher absentee rates and teacher/administrator collaboration.
Learning Spaces in the Community (3.07)
If the daily life of the school is well-integrated into the community, students will feel that their work is more meaningful, that the school is investing in their ongoing lives. Students will be more connected to the adult community around them, increasing their social development and reducing their transience. Local businesses will be more familiar with the students, more willing to engage them as customers and workers. Both students and parents will report increased satisfaction with the school.
The school as the center of a community expands students awareness of education and promotes good citizenship
Outdoor Learning Spaces (3.06)
Outdoor learning spaces will increase learning opportunities and affect student performance
A Building of Niches (3.00)
Places for students to meet outside the classroom will promote social interaction and enhance their social skills
Spaces to Accommodate Different Size Groups (3.00)
Spatial variety will allow for a variety of student experiences that will affect their academic performance
Autonomy of Access to Group Work Area (2.88)
Autonomy of access to group work areas in schools that practice project-based education will create a sense of ownership in students that may lead to better attitudes toward school and motivation to learn that will positively influence their performance, greater student attendance and overall success in school, socially and academically.

Appendix M (cont'd).

Location that is Convenient to Community Resources (2.75)
School location that is convenient to community resources (immediately adjacent/proximate to zoos, parks, libraries, partnering businesses) will be more likely to forge partnerships and joint use agreements that may lead to more contextualized, real-world learning for students (moderated by teacher quality – motivation to create and maintain these partnerships) that may lead to an improved sense of relevance of learning to their own lives, improve the social climate and culture within the school, build community capital that will overtime lead to the academic growth of students, greater attendance by students, teacher/administrative retention, school connectedness, affective performance.
Age of the School Building (2.63)
Students in old buildings will score lower on measures of achievement than will students in modern buildings.
Newer buildings positively affect student attitudes/performance. (However, I found this did not matter in my study, and don't think age really matters, but condition does - I think age only matters in terms of the newest facilities not having the time to deteriorate.
* These hypotheses appear under 2 separate physical item categories, since the respondent listed them as such. However, the total number of hypotheses (counting repeated ones only once) is 107.

APPENDIX N

FRAMEWORK OF PHYSICAL VARIABLES PLAUSIBLY RELATED TO EDUCATIONAL OUTCOMES: VERSION 3

FUNCTIONALITY

Building Identity and Recognition

Infusion of students' culture into the fabric of the building
Incorporation of student work into the school building

Building Legibility

Signage
Relationship of spaces within building (i.e., how spaces for different types of activities are interconnected)
Color and lighting for spatial delineation
Floor plan layout

Spatiality and Scale

Size of school grounds
School building size (e.g., square footage)
"Schools within a school": learning "houses" with clear, identifiable boundaries if large school
Learning environment size (e.g., classroom square footage)
Learning environment geometric shape (e.g., fat-L, square, rectangular)
Scale of building elements relative to one another
Academic Grade configuration (refers to the manner in which grade levels are organized into a single school, e.g. K-3, K-5, K-12)
Food service areas (location and accessibility)

Crowdedness or spaciousness

Overcrowded conditions (possibly determined by % capacity for school achieved, square foot per child in the classroom)
Size and shape of circulation spaces
Space to keep items (e.g., coats, boots) from lying around and appearing "messy"

Flexibility

Site – the grounds that surround a school building.
(flexibility refers to having a site that accommodates diverse activities and changing needs)

School building or buildings (flexibility may refer to the ability to add on or renovate to meet changing needs)
Learning environment (e.g., movable walls, portable equipment, etc)
Furnishings (seating that is comfortable and accommodating; diverse work surfaces - heights, sizes and shapes)
Distribution of outlet to support information technology and provide electricity

Instructional Support

Library
Music rooms
Science laboratories
Physical education facilities
Professional spaces for teachers (including work rooms, lounges, offices, professional library)
Outdoor learning spaces (natural, man-made) - availability and their location
Spaces for building models, art work, etc.

Conveniences

Lockable, personalized storage
Student accessible files (students create and maintain an individual learning plan, portfolio of learning evidence)
Secure storage of collective projects in process

SOCIABILITY

Collaboration and social interaction

Access to group work area (allows team members to work on projects as mood and/or opportunity strikes)
Team workstations/shared spaces
Spaces to accommodate different size groups
Presentation area – present acquired knowledge, skills and abilities
A building of niches (allows many small groups to claim space and meet in regular locations)
Spaces for display of ideas, processes, projects and products
Spaces for production: design, testing and evaluation, and application of products (student developed – even products to sell)
A town square (large area all pass through)
Commons areas appropriate for age group
Informal learning spaces where students, teachers, and staff can further learn beyond the confines of the "classroom"
Space supporting multi-disciplinary activities
Faculty collaborative space

Conference spaces

Interior windows for viewing of instructional areas

Privacy

Spaces for quiet reflection (however created – furnishings, walls, doors, etc.) for both students and faculty
Individual workspace (student "owned," allows a quiet home base, control of the modes of work)

Autonomy

Freedom of access to environment housing computers and library materials
Freedom of access to group work area
Spaces for students to personalize
Multiple access points and time availability to food and beverages

COMFORT, HEALTH & SAFETY

Acoustical comfort

Interior noise (e.g., ambient, inside the learning environment)
External noise (e.g., aircraft, highway)
Acoustic privacy from other groups
Individual control over acoustical conditions (e.g., closing of door and window)

Visual comfort

Natural lighting (e.g., windows, clerestories, skylights)
Electric lighting (general, task)
Visual conditions (glare, contrast between print and paper, etc.)
Views to the outside
Individual control over visual conditions (e.g., illumination level)

Thermal comfort

Air-conditioning for cooling (e.g., presence, type)
Heating
Relative humidity
Individual control over thermal conditions (e.g., ventilation, temperature)

Indoor air quality (real and perceived)

Adequate ventilation

Presence or absence of pollutants indoors (e.g., mold, VOCs, etc.)

Safety and security (real and perceived)

Sight lines within building
Child's perceived safety
Telephones in classroom (more important as a resource for project-based learning when projects are community based, however, serve as a back-up security device)

AESTHETICS & APPEARANCE

Sensory stimulation (appropriate, but not excessive)

Floor coverings
Wall coverings or treatments
Colors
Neat rather than chaotic display systems

Maintenance

Cleanliness (upkeep, sanitary conditions)
Quality of learning environment conditions (appearance of furniture, walls, etc.: deteriorating plaster, water stains, paint condition)
Age of the school building
Building improvements/modernization

RESOURCES

Community Resources

Visitors easily accommodated (parking, access, work areas)
Proximity of school building to community
Space for community and business representatives, volunteers, and parents within the school
Learning spaces within the community - shared spaces such as libraries, physical fitness centers, museums,
Small business incubator space

Technology Resources (students and staff)

Computers and Internet access
Accessible phone, copiers, fax – especially important if students are working with business and community partners in producing “real world” solutions

School building as a teaching tool (e.g., observed power generation from solar panel)

Human Resources (within the school)

Spatial integration of teachers, counselors and students for access to intellectual and career advice
(advice is obtained without special trips through unwelcoming main administrative territory)

NOTE: When spaces are listed above, "the provision of …" is implied but not stated. For example, Presentation Area means, "the provision of a presentation

SURVEY 4a: Selecting Priority Hypotheses

The following hypotheses were submitted by panel members in response to survey 3. These are hypotheses regarding links between physical school factors and measures of success that panel members believe are important to study, given funding to do so. Basically, these are items that would be listed in a research agenda for this field of research. The list of hypotheses has been shortened (although you may find that hard to believe) by omitting redundant hypotheses. You may wish to print them.

Please select 10 of the following hypotheses that you believe should be part of a research agenda (studied first) by placing an "X" in Column B beside each hypothesis. If you feel strongly that the wording of the hypothesis should be changed, please write an alternate in Column C.

Physical Item	Top 10 Hypotheses (place X by 10 of these)	Reworded Hypothesis
Combinations of Physical Factors		
A combination of individual student workspace, spaces for students to personalize and lockable personal storage will create a sense of ownership in students that may lead to better attitudes toward school and motivation to learn that will positively influence their performance, greater student attendance and overall success in school, socially and academically.		

Circulation spaces designed with niches, benches, seating areas, natural light will provide opportunities for students and teachers to informally interact as they move through the building that may support an improved social climate and culture and build social capital within the school that will overtime lead to the academic growth of students, greater attendance by students, teacher/administrative retention, school connectedness, affective performance, as well as create a student friendly environment.		
Learners have an increased desire to learn when they have access to appropriate technology, equipment, and information to discover and create new knowledge		
Increasing learner to learner, learner to teacher, and teacher to teacher interactions provides a greater depth of knowledge acquisition and increased ability to resolve conflicts, problem solve, and work in teams.		
Providing learning environments that closely resemble "next-steps-in-life" environments better prepares learners to be successful throughout life.		
When psychological and physiological needs (natural light, comfortable-flexible furnishings, sense of connection or belonging) are met the learner is better prepared to contribute to and absorb new information.		
Well designed learning environments that support and enhance learning increase retention and satisfaction among students, teachers, and staff.		
Community involvement and project-based learning prepares learners for work, family, community, and personal life.		
A less formal structure of schooling (I.e. social interaction, overviews) may provide greater opportunities for student academic achievement (Re: Circulation Spaces that Promote Social Interaction and Provide Opportunities to View Other Learning Environments - NR)		
Telephones in Classroom		
Telephones in the classroom increase the number of parent contacts*		

Appendix O (cont'd).

Overcrowded Conditions		
Students in over-utilized buildings will score lower on measures of student performance and have lower attendance rates than students in properly utilized buildings.		
A learning space that is too small for the number of occupants (I.e. feels "overcrowded) will result in adverse behavior for all involved acting as a mediating variable affecting a host of academic and teacher job satisfaction related measures.		
Overcrowded conditions, especially as measured by classroom spatial density may create physiological and psychological stress in students decreasing their mental concentration and ability to focus on tasks (moderated by quality and quantity of student-teacher interaction) and may over time affect their achievement as measured by reading readiness, mathematics scores.		
Reduction of class size will result in increased attentiveness and consequently reduce absenteeism		
Daylighting		
Natural illumination of general learning spaces (with controls such as blinds or screens) help improve human behavior thereby mediating academic and teacher job satisfaction measures.		
Daylighting has been shown (Heschong-Mahone study) to have a significant impact on elementary level student performance. It can be assumed that these same benefits persist in middle and high school environments that have high levels of daylight in the classrooms.		
(Re: daylighting) Lack of light affects moods as well as effort on task		
Daylight in the classroom can create a pleasant environment and improve student performance		

Appendix O (cont'd).

Students in daylit classrooms will score higher in achievement tests than students in classrooms without natural daylight. Daylit classrooms will experience lower absentee rates than non-daylit classrooms. Teachers in daylit classrooms will express higher job satisfaction than teachers in non-daylit classrooms. Daylit classrooms will experience fewer student suspensions than non-daylit classrooms.		
Indoor Air Quality/ Presence or Absence of Pollutants		
Perceived indoor pollution within a school building will have adverse affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures.		
Poor indoor air quality, especially ventilation, may negatively impact student health leading to a decreased focus on learning tasks while in school, and lower attendance in school due to sickness that may over time affect their achievement (reading readiness and mathematics).		
Classrooms with poor IAQ will have higher asthma rates than classrooms with good IAQ. Classrooms with poor IAQ will have higher student and teacher absentee rates than classrooms with good IAQ. Test scores of students in classrooms with IAQ problems will be lower than those of students in classrooms with good IAQ.		
Student test scores in elementary schools correlate positively with indoor air quality in the classroom.		
Adequate Ventilation		
Adequate ventilation of general learning spaces (with controls such as blinds or screens) help improve human behavior thereby mediating academic and teacher job satisfaction measures.		
Ventilation systems that provide 100% outside air positively impact student health and reduce absenteeism due to illness.		
Internal Noise		
Excessive internal noise generated and reflected within a learning space will adversely affect (moderate) student performance and diminish teacher job satisfaction.		

Interior noise negatively impacts a student's ability to learn. This is particularly true in the early grades (elementary and middle school) and in students with hearing impairments and/or for whom English is a second language		
Interior background noise may produce [reduced] intelligibility of the teacher's voice as well as produce fatigue in students that may affect their mental concentration and ability to focus on tasks and may over time affect their achievement as measured by reading readiness, mathematics scores.		
Unwanted noise in the classroom can create distractions and become a source of disturbance		
In classroom with significant background noise (HVAC system, etc.), students who sit closer to teacher will have higher achievement scores than those who sit far away from the teacher.		
Students in buildings that are excessively noisy will perform lower on measures of achievement than students in quiet buildings.		
External Noise		
Excessive external noise transmitted within a learning space will adversely affect (moderate) student performance and diminish teacher job satis faction.		
(Re: external noise) External noise can create distractions and reduce student performance		
Schools in close proximity to airports will have higher incidence of learning disabilities.		
Quality of Learning Environment Conditions		
If all members of the school community perceive the school environment to be of high quality, this will improve self-reported satisfaction with the school among teachers, administrators, students, parents and community members.		
Students in buildings that are well maintained will perform higher on measures of achievement than will students in poorly maintained buildings.		

Perceived poor physical environmental conditions will have adverse affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures. (Also referring to cleanliness)		
Poor physical conditions are associated with poorer academic achievement - for the same reason poor working conditions in business environment are assumed to cause lower worker productivity - people in poor environments do not feel valued, there are distractions, etc. (Also referring to cleanliness)		
Environment affects moods, might encourage improved behavior		
Perception of a positively designed physical environmental can have positive affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures.		
Cleanliness		
If all members of the school community perceive the school environment to be clean and well maintained, this will improve self-reported satisfaction with the school among teachers, administrators, students, parents and community members.		
Perceived cleanliness can affect student's pride in their school and reduce vandalism		
Schools that are not clean or aesthetically attractive will have higher rates of student discipline problems than schools that are attractive, well kept and clean.		
School maintenance can influence students' attitudes toward their school (including pride about their school) and subsequently vandalism*		
Electric Lighting		
Adequate electric illumination AND control promotes (mediates) general teacher job satisfaction measures.		
Pendant-mounted, indirect lighting fixtures provide a more effective ambient light environment than downlights, resulting in better student performance.		

Appendix O (cont'd).

Air Conditioning		
Adequately mechanical cooled and humidified air (with controls) promotes (mediates) general teacher job satisfaction measures and to some degree moderates student performance.		
Students in classrooms without air conditioning (at higher temperatures) will experience lower test scores, more behavior problems, higher absentee rates than students in classrooms with AC.		
Students in buildings that have air conditioning in the classrooms will score higher on measures of academic achievement than will students in non-air-conditioned buildings.		
Individual Control Over Thermal Conditions (e.g., ventilation, temperature)		
Adequate controls of mechanical systems promotes (mediates) general teacher job satisfaction measures and to some degree moderates student performance.		
Student's control over their immediate environment will affect their comfort and consequently their performance		
Being able to modify or control the ambient conditions in the learning environment improves learning.		
Visual conditions that affect occupants' ability to read and see comfortably such as glare, contrast between print and paper, etc.		
Adequately designed and controlled illumination of general learning spaces help improve human behavior thereby mediating academic and teacher job satisfaction measures.		
Glare and other negative visual conditions can be 'designed out' of a school classroom, resulting in better performance on all visual tasks, including reading and mathematics.		
The presence of glare on work surfaces and computer screens may produce eye strain in students that may affect their mental concentration and ability to focus on tasks (and while moderated by their ability to control glare) and may over time affect their achievement as measured by reading readiness, mathematics scores.		
Visual discomfort will affect their attentiveness and subsequently student performance		
Students in buildings that have good lighting will perform higher on measures of achievement than will students in classrooms that have poor lighting.		

Freedom of access to academic research material (together with mentored support in use strategies) improves (moderates) academic and professional development in schools.		
Science Labs		
Poor equipment can destroy interest in science		
Students in laboratories that have modern furniture and equipment will score higher on science tests than will students who have non-functioning and old furniture and equipment.		
Counseling Services		
If counseling services are located in high-traffic public areas, this will boost student use of such resources in both scheduled and casual ways. Students will feel both welcome within adult structures and also better informed about their academic options and their post-secondary choices. This will boost both student and parent attitudes with regards to the school as a whole.		
Close access to counselors among the learning areas promote (mediate) student behavior and consequent academic improvement		
Easily accessible career advice will ease anxiety about future options so students are better prepared after graduation		
Views to the Outside		
External views from general learning spaces help improve human behavior thereby mediating academic and teacher job satisfaction measures.		
Views to the outside of any given space, especially to daylit outdoors, may decrease eye fatigue thereby allowing a student to maintain mental concentration and focus on the leaming task (moderated by classroom management policy of teacher, that is, students being allowed to stare out the window on occasion) and will over time improve their achievement as measured by reading readiness, and mathematics scores.		
Views to the outside will affect the classroom atmosphere and subsequently students' performance		

Furnishings/Seating		
If seating is easily manipulable to suit multiple pedagogic purposes, this will increase the range of classroom experiences that students and teachers can employ. This will increase the range of classroom experiences that students and teachers can employ. The broader possible range of pedagogical strategies will lead to increased student academic growth, and will also reduce off-task behavior stemming either from boredom or from working at cross-purposes to the demands/affordances of a static environment		
Adequate, well designed furniture that may be rearranged for appropriate academic and social activities positively affects (mediates) student behavior and teacher job satisfaction.		
Flexible seating allows students to work individually or in groups and engage in more intimate contact with the teacher		
The ability for students to modify their environment will affect the variety of experiences and activities and consequently a positive attitude towards education		
Faculty Collaborative Space		
The presence of faculty collaborative space, when combined with a school schedule and culture that makes its use the norm, will have countless benefits. Teachers will be more supported by their peers and administrators, and new teachers will be mentored more authentically, with greater participation in professional development. Teacher satisfaction will rise, and faculty attrition and absences will both be reduced. Because teachers will be able to collaborate over difficulties of specific students, those students will be more productive, have better attitudes, and be socially supported (all increasing parental satisfaction and reducing student transience).		
Collaborative workspaces provide an opportunity for positive interaction among teachers helping to build an interactive learning culture that improves overall student academic achievement and teacher job satisfaction.		
Space for faculty planning allows for teaming and an opportunity for their professional growth		

Building Improvements		
Perception of an improved positively designed physical environmental can have positive affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures.		
Students in well-maintained buildings of good quality will score higher in achievement tests than students in poor quality buildings. Disciplinary problems will be higher in poorly maintained buildings than in good or excellent school buildings. Poorly maintained buildings will experience higher absentee rates than good or excellent buildings.		
Team Workstations/ Shared Spaces		
The availability for students to work comfortably and productively in teams will increase the range of opportunities for both academic and social growth. Students will be more positive about their school, feel more socially connected, and reduce off-task time through ease of using team-based environments. Faculty and parents will both report increased satisfaction with student learning and with the school environment.		
Team workstations encourage group work and prepare students for future collaborative employment		
Conference Spaces		
Close access to private conference rooms among the learning areas promote (mediate) student behavior and consequent academic improvement		
Spaces for Quiet Reflection		
The ability for students and faculty alike to find and take advantage of private, quiet space will improve both satisfaction and performance among both groups. Student social development and general affect will be improved through the ability to self-regulate social interaction, and off-task behavior will be reduced through providing quiet space for individual and reflective work.		
Spaces for quiet reflection may improve order and reduce disciplinary problems		

Appendix O (cont'd).

Spaces for quiet reflection will minimize student aggression and hostility		
Access to and ownership of quiet, reflective spaces promote (mediate) student behavior and consequent academic improvement		
Informal Learning Spaces		
When teachers and students are encouraged to meet informally, this will improve the sense of connectedness of both groups, and the school will be perceived as strongly student-friendly. Satisfaction with the school will increase among all parties involved (including parents), and student performance will increase through greater access to faculty.		
Opportunities for social interaction outside the classroom will have a positive affect on their attitude towards education and academic performance		
Control Over Thermal, Visual and Acoustical Conditions		
Adequate controls of building systems promotes (mediates) general teacher job satisfaction measures and to some degree, moderates student performance.		
A controlled study will indicate higher levels of teacher satisfaction in spaces where rudimentary control over interior thermal, visual and acoustical conditions are provided. Satisfaction does not increase as the level of control increases. The presence or absence of some form of control is the most important factor.		
Ability for students to control the thermal environment will affect their comfort and subsequently academic performance		
Adult-Student Spatial Integration		
Integration of all learning spaces into heterogeneous groupings promote (mediate) student and teacher behavior and consequent academic improvement		

Appendix O (cont'd).

Display Space and Studios for Ideas, Processes, Projects and Products		
Display spaces for student (and teacher) work promote (mediate) student and teacher behavior and consequent academic improvement		
Display space for student work will enhance their self image and subsequently their academic performance		
Learning Environment Size		
The size of the learning environment will influence the seating arrangement and the way that teachers move about the classroom to interact with students		
Acoustical Privacy From Other Groups		
Lack of acoustical privacy within a learning space will adversely affect (moderate) student performance and diminish teacher job satisfaction.		
Relationship of Spaces Within Building		
Spatial organization will affect the amount of social contacts in the school expanding learning opportunities outside of the classroom		
Shape of Learning Environment		
The shape of the learning environment can influence the organization of seating that afford opportunities for group and individual work to occur simultaneously		
Spaces for Students to Personalize		
The ability for students to personalize their environment will affect their self image and minimize vandalism		
School Building Size		
The physical school size affects the possibilities for teacher-student-community interaction and consequent resulting cohesion or friction that may affect student academic progress.		

Professional Spaces for Teachers		
Professional spaces for teachers that include workrooms, and especially private offices, will create a sense of ownership in teachers that may lead to better attitudes toward their workplace and motivate them to improve their teaching practice that may lead to better teacher retention, lower teacher absentee rates and teacher/administrator collaboration.		
Learning Spaces in the Community		
If the daily life of the school is well-integrated into the community, students will feel that their work is more meaningful, that the school is investing in their ongoing lives. Students will be more connected to the adult community around them, increasing their social development and reducing their transience. Local businesses will be more familiar with the students, more willing to engage them as customers and workers. Both students and parents will report increased satisfaction with the school.		
The school as the center of a community expands students awareness of education and promotes good citizenship		
Outdoor Learning Spaces		
Outdoor learning spaces will increase learning opportunities and affect student performance		
A Building of Niches		
Places for students to meet outside the classroom will promote social interaction and enhance their social skills		
Spaces to Accommodate Different Size Groups		
Spatial variety will allow for a variety of student experiences that will affect their academic performance		

Autonomy of Access to Group Work Area		
Autonomy of access to group work areas in schools that practice project-based education will create a sense of ownership in students that may lead to better attitudes toward school and motivation to learn that will positively influence their performance, greater student attendance and overall success in school, socially and academically.		
Location that is Convenient to Community Resources		
School location that is convenient to community resources (immediately adjacent/proximate to zoos, parks, libraries, partnering businesses) will be more likely to forge partnerships and joint use agreements that may lead to more contextualized, real-world learning for students (moderated by teacher quality – motivation to create and maintain these partnerships) that may lead to an improved sense of relevance of learning to their own lives, improve the social climate and culture within the school, build community capital that will, over time, lead to the academic growth of students, greater attendance by students, teacher/administrative retention, school connectedness, affective performance.		
Age of the School Building		
Students in old buildings will score lower on measures of achievement than will students in modern buildings.		
Newer buildings positively affect student attitudes/performance. (However, I found this did not matter in my study, and don't think age really matters, but condition does - I think age only matters in terms of the newest facilities not having the time to deteriorate.		

PLEASE CLICK ON THE SHEET 2 TAB BELOW TO COMPLETE SURVEY 4B

SURVEY 4b: Revised Framework of Physical Factors That May Affect Educational Outcomes

Please review the following Framework. This has been edited based on panel member comments. Please provide any additional comments (please be very specific) in Column B regarding modifications that you believe are necessary to improve the framework.

FUNCTIONALITY	**COMMENTS**
Building Identity and Recognition	
Infusion of students' culture into the fabric of the building	
Incorporation of student work into the school building	
Building Legibility	
Signage	
Relationship of spaces within building (i.e., how spaces for different types of activities are interconnected)	
Color and lighting for spatial delineation	
Floor plan layout	
Spatiality and Scale	
Size of school grounds	
School building size (e.g., square footage)	
"Schools within a school": learning "houses" with clear, identifiable boundaries if large school	

Learning environment size (e.g., classroom square footage)

Learning environment geometric shape (e.g., fat-L, square, rectangular)

Scale of building elements relative to one another

Academic Grade configuration (refers to the manner in which grade levels are organized into a single school, e.g. K-3, K-5, K-12)

Food service areas (location and accessibility)

Crowdedness or spaciousness

Overcrowded conditions (possibly determined by % capacity for school achieved, square foot per child in the classroom)

Size and shape of circulation spaces

Space to keep items (e.g., coats, boots) from lying around and appearing "messy"

Flexibility

Site – the grounds that surround a school building.

(flexibility refers to having a site that accommodates diverse activities and changing needs)

School building or buildings (flexibility may refer to the ability to add on or renovate to meet changing needs)

Learning environment (e.g., movable walls, portable equipment, etc)

Furnishings (seating that is comfortable and accommodating; diverse work surfaces - heights, sizes and shapes)

Distribution of outlet to support information technology and provide electricity

Instructional Support

Library

Music rooms

Science laboratories

Physical education facilities

Professional spaces for teachers (including work rooms, lounges, offices, professional library)

Outdoor learning spaces (natural, man-made) - availability and their location

Spaces for building models, art work, etc.

Conveniences

Lockable, personalized storage

Student accessible files (students create and maintain an individual learning plan, portfolio of learning evidence)

Secure storage of collective projects in process

SOCIABILITY

Collaboration and social interaction

Access to group work area (allows team members to work on projects as mood and/or opportunity strikes)

Team workstations/shared spaces

Spaces to accommodate different size groups

Presentation area – present acquired knowledge, skills and abilities

A building of niches (allows many small groups to claim space and meet in regular locations)

Spaces for display of ideas, processes, projects and products

Spaces for production: design, testing and evaluation, and application of products (student developed – even products to sell)

A town square (large area all pass through)

Commons areas appropriate for age group

Informal learning spaces where students, teachers, and staff can further learn beyond the confines of the “classroom”

Space supporting multi-disciplinary activities

Faculty collaborative space

Conference spaces

Interior windows for viewing of instructional areas

Privacy

Spaces for quiet reflection (however created – furnishings, walls, doors, etc.) for both students and faculty

Individual workspace (student “owned,” allows a quiet home base, control of the modes of work)

Autonomy

Freedom of access to environment housing computers and library materials

Freedom of access to group work area

Spaces for students to personalize

Multiple access points and time availability to food and beverages

COMFORT, HEALTH & SAFETY

Acoustical comfort

Interior noise (e.g., ambient, inside the learning environment)

External noise (e.g., aircraft, highway)

Acoustic privacy from other groups

Individual control over acoustical conditions (e.g., closing of door and window)

Visual comfort

Natural lighting (e.g., windows, clerestories, skylights)

Electric lighting (general, task)

Visual conditions (glare, contrast between print and paper, etc.)

Views to the outside

Individual control over visual conditions (e.g., illumination level)

Thermal comfort

Air-conditioning for cooling (e.g., presence, type)

Heating

Relative humidity

Individual control over thermal conditions (e.g., ventilation, temperature)

Indoor air quality (real and perceived)

Adequate ventilation

Presence or absence of pollutants indoors (e.g., mold, VOCs, etc.)

Safety and security (real and perceived)

Sight lines within building

Child's perceived safety

Telephones in classroom (more important as a resource for project-based learning when projects are community based, however, serve as a back-up security device)

AESTHETICS & APPEARANCE

Sensory stimulation (appropriate, but not excessive)

Floor coverings

Wall coverings or treatments

Colors

Neat rather than chaotic display systems

Maintenance

Cleanliness (upkeep, sanitary conditions)

Quality of learning environment conditions (appearance of furniture, walls, etc.: deteriorating plaster, water stains, paint condition)

Age of the school building

Building improvements/modernization

RESOURCES

Community Resources

Visitors easily accommodated (parking, access, work areas)

Proximity of school building to community

Space for community and business representatives, volunteers, and parents within the school

Learning spaces within the community - shared spaces such as libraries, physical fitness centers, museums,

Small business incubator space

Technology Resources (students and staff)

Computers and Internet access

Accessible phone, copiers, fax – especially important if students are working with business and community partners in producing "real world" solutions

School building as a teaching tool (e.g., observed power generation from solar panel)

Human Resources (within the school)

Spatial integration of teachers, counselors and students for access to intellectual and career advice

(advice is obtained without special trips through unwelcoming main administrative territory)

NOTE: When spaces are listed above, "the provision of …" is implied but not stated. For example, Presentation Area means, "the provision of a presentation area"

APPENDIX P

PRIORITY HYPOTHESES SELECTED BY RESEARCHERS

Physical Item/Hypothesis	**Selected by**	**Reworded Hypothesis**	**Comments**
Combinations of Physical Factors			
A combination of individual student workspace, spaces for students to personalize and lockable personal storage will create a sense of ownership in students that may lead to better attitudes toward school and motivation to learn that will positively influence their performance, greater student attendance and overall success in school, socially and academically.	2		
Circulation spaces designed with niches, benches, seating areas, natural light will provide opportunities for students and teachers to informally interact as they move through the building that may support an improved social climate and culture and build social capital within the school that will overtime lead to the academic growth of students, greater attendance by students, teacher/administrative retention, school connectedness, affective performance, as well as create a student-friendly environment.	4		
Learners have an increased desire to learn when they have access to appropriate technology, equipment, and information to discover and create new knowledge	2	Learners have an increased desire to learn when they are engaged in relevant, meaningful tasks and have access to appropriate technology, equipment, and information to discover and create knowledge.	

Increasing learner to learner, learner to teacher, and teacher to teacher interactions provides a greater depth of knowledge acquisition and increased ability to resolve conflicts, problem solve, and work in teams.	1		
Providing learning environments that closely resemble "next-steps-in-life" environments better prepares learners to be successful throughout life.	1	Providing learning environments that closely resemble "nest-steps-in-life" environments and involves the community and project-based learning better prepares learners to be successful in life roles throughout their lives.	
When psychological and physiological needs (natural light, comfortable-flexible furnishings, sense of connection or belonging) are met the learner is better prepared to contribute to and absorb new information.	2	When psychological and physiological needs (natural light, views to the outside, comfortable and flexible furnishings, access to food and beverage, sense of connection or belonging) are met the learner is better prepared to contribute to and absorb new information.	
Well-designed learning environments that support and enhance learning increase retention and satisfaction among students, teachers, and staff.	2		too broad, can't be reworded. If you did reword, have retention and satisfaction leading to increases in learning. (diff respondent)
Community involvement and project-based learning prepares learners for work, family, community, and personal life.	1	Physical settings designed to support project-based learning will prepare learners…	
A less formal structure of schooling (i.e. social interaction, overviews) may provide greater opportunities for student academic achievement (Re: Circulation Spaces that Promote Social Interaction and Provide Opportunities to View Other Learning Environments - NR)	2		don't know what you mean by "formal structure of schooling"

Appendix P (cont'd).

Overcrowded Conditions			
Students in over-utilized buildings will score lower on measures of student performance and have lower attendance rates than students in properly utilized buildings.	4		
Reduction of class size will result in increased attentiveness and consequently reduce absenteeism.	2	Reduction of class size will result in increased teacher contact time, increased student attentiveness to the learning task.	*not same respondent that suggested rewording*
Daylighting			
Daylighting has been shown (Heschong-Mahone study) to have a significant impact on elementary level student performance. It can be assumed that these same benefits persist in middle and high school environments that have high levels of daylight in the classrooms.	1		
Students in daylit classrooms will score higher in achievement tests than students in classrooms without natural daylight. Daylit classrooms will experience lower absentee rates than non-daylit classrooms. Teachers in daylit classrooms will express higher job satisfaction than teachers in non-daylit classrooms. Daylit classrooms will experience fewer student suspensions than non-daylit classrooms.	3	Students in predominantly daylit classrooms will perform higher than students in classrooms that are predominately artificially illuminated; Non-testable in present wording. "Students in classrooms with daylighting features will score higher in achievement tests and have lower absentee rates than students in classrooms without daylighting features..…	

Appendix P (cont'd).

Indoor Air Quality/ Presence or Absence of Pollutants			
Poor indoor air quality, especially ventilation, may negatively impact student health leading to a decreased focus on learning tasks while in school, and lower attendance in school due to sickness that may over time affect their achievement (reading readiness and mathematics).	1		there are a number of linked hypotheses here that would need to be tested
Classrooms with poor IAQ will have higher asthma rates than classrooms with good IAQ. Classrooms with poor IAQ will have higher student and teacher absentee rates than classrooms with good IAQ. Test scores of students in classrooms with IAQ problems will be lower than those of students in classrooms with good IAQ.	2		
Internal Noise			we know noise is bad, lets focus our research dollars on areas we don't know as much about……
Excessive internal noise generated and reflected within a learning space will adversely affect (moderate) student performance and diminish teacher job satisfaction.	2		
Students in buildings that are excessively noisy will perform lower on measures of achievement than students in quiet buildings.	1		
Quality of Learning Environment Conditions			too broad a topic to investigate as stated
Students in buildings that are well maintained will perform higher on measures of achievement than will students in poorly maintained buildings.	3		

Appendix P (cont'd).

Perceived poor physical environmental conditions will have adverse affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures. (Also referring to cleanliness)	1		
Poor physical conditions are associated with poorer academic achievement - for the same reason poor working conditions in business environment are assumed to cause lower worker productivity - people in poor environments do not feel valued, there are distractions, etc. (Also referring to cleanliness)	2		
Perception of a positively designed physical environmental can have positive affects on occupant attitudes thus mediating student academic and teacher job satisfaction measures.	1	Perception of a well designed, clean and maintained physical environment can have positive effects on students, teachers, administrators, parents, and community members.	
Cleanliness			we may not have empirical data on this topic, but it seems a no-brainer to most - wouldn't spend the time and money needed to prove what people already believe.
If all members of the school community perceive the school environment to be clean and well maintained, this will improve self-reported satisfaction with the school among teachers, administrators, students, parents and community members.	1		
Perceived cleanliness can affect student's pride in their school and reduce vandalism	1		

Appendix P (cont'd).

Schools that are not clean or aesthetically attractive will have higher rates of student discipline problems than schools that are attractive, well kept and clean.	2	Not a well-defined hypothesis. Students in school buildings that are not kept clean and aesthetically attractive ill exhibit higher rates of discipline problems than will students in clear and attractive buildings.	
School maintenance can influence students' attitudes toward their school (including pride about their school) and subsequently vandalism*	2		
Air Conditioning			Air conditioning is a small part of a larger issue of high performance. I wouldn't place specific focus on it solely.
Students in classrooms without air conditioning (at higher temperatures) will experience lower test scores, more behavior problems, higher absentee rates than students in classrooms with AC.	1		
Students in buildings that have air-conditioning in the classrooms will score higher on measures of academic achievement than will students in non aid-conditioned buildings.	1		
Individual Control Over Thermal Conditions (e.g., ventilation, temperature)			
Being able to modify or control the ambient conditions in the learning environment improves learning.	1	Having adequate, self-controlled heating, cooling, ventilation, lighting, and noise control in the learning environment improves learning.	Only if you know HOW to modify and control! This one is tough to study.

Appendix P (cont'd).

Visual conditions that affect occupants' ability to read and see comfortably such as glare, contrast between print and paper, etc.			
Adequately designed and controlled illumination of general learning spaces help improve human behavior thereby mediating academic and teacher job satisfaction measures.	1		
Students in buildings that have good lighting will perform higher on measures of achievement than will students in classrooms that have poor lighting.	2		
Science Labs			
Students in laboratories that have modern furniture and equipment will score higher on science tests than will students who have non-functioning and old furniture and equipment.	1	Students using science laboratories that have modern furniture and equipment will score higher on science tests than will students who have non-functioning or old furniture and equipment.	
Counseling Services			
If counseling services are located in high-traffic public areas, this will boost student use of such resources in both scheduled and casual ways. Students will feel both welcome within adult structures and also better informed about their academic options and their post-secondary choices. This will boost both student and parent attitudes with regards to the school as a whole.	2		
Views to the Outside			
Views to the outside will affect the classroom atmosphere and subsequently students' performance	2		

Appendix P (cont'd).

Furnishings/Seating			
If seating is easily manipulable to suit multiple pedagogic purposes, this will increase the range of classroom experiences that students and teachers can employ. This will increase the range of classroom experiences that students and teachers can employ. The broader possible range of pedagogical strategies will lead to increased student academic growth, and will also reduce off-task behavior stemming either from boredom or from working at cross-purposes to the demands/affordances of a static environment.	3		"range of classroom experiences"— how defined?
Adequate, well-designed furniture that may be rearranged for appropriate academic and social activities positively affects (mediates) student behavior and teacher job satisfaction.	1		
Faculty Collaborative Space			
The presence of faculty collaborative space, when combined with a school schedule and culture that makes its use the norm, will have countless benefits. Teachers will be more supported by their peers and administrators, and new teachers will be mentored more authentically, with greater participation in professional development. Teacher satisfaction will rise, and faculty attrition and absences will both be reduced. Because teachers will be able to collaborate over difficulties of specific students, those students will be more productive, have better attitudes, and be socially supported (all increasing parental satisfaction and reducing student transience).	4		

Collaborative workspaces provide an opportunity for positive interaction among teachers helping to build an interactive learning culture that improves overall student academic achievement and teacher job satisfaction.	4		This one might be folded into the previous
Building Improvements			
Students in well-maintained buildings of good quality will score higher in achievement tests than students in poor quality buildings. Disciplinary problems will be higher in poorly maintained buildings than in good or excellent school buildings. Poorly maintained buildings will experience higher absentee rates than good or excellent buildings.	3	Non-testable in present state. Students in well-maintained buildings of good quality will score higher on achievement tests and create fewer disciplinary problems than will students in buildings that are not well maintained and of poor quality.	Again, WHY???? The other better hypotheses above should answer this much more general hypo (different respondent)
Team Workstations/ Shared Spaces			
The availability for students to work comfortably and productively in teams will increase the range of opportunities for both academic and social growth. Students will be more positive about their school, feel more socially connected, and reduce off-task time through ease of using team-based environments. Faculty and parents will both report increased satisfaction with student learning and with the school environment.	6	Shared spaces for faculty planning and for learning/teaching will increase opportunities to use a variety of pedagogical techniques, a sense of being more socially connected, and satisfaction among teachers, students, and parents.	
Team workstations encourage group work and prepare students for future collaborative employment	1		

Appendix P (cont'd).

Spaces for Quiet Reflection			
The ability for students and faculty alike to find and take advantage of private, quiet space will improve both satisfaction and performance among both groups. Student social development and general affect will be improved through the ability to self-regulate social interaction, and off-task behavior will be reduced through providing quiet space for individual and reflective work.	4	Available quiet spaces for individual work and reflection for both faculty and students will improve performance and sense of satisfactions.	
Access to and ownership of quiet, reflective spaces promote (mediate) student behavior and consequent academic improvement	1		
Informal Learning Spaces			
When teachers and students are encouraged to meet informally, this will improve the sense of connectedness of both groups, and the school will be perceived as strongly student-friendly. Satisfaction with the school will increase among all parties involved (including parents), and student performance will increase through greater access to faculty.	2		
Opportunities for social interaction outside the classroom will have a positive affect on their attitude towards education and academic performance	1		

Control Over Thermal, Visual and Acoustical Conditions			
A controlled study will indicate higher levels of teacher satisfaction in spaces where rudimentary control over interior thermal, visual and acoustical conditions are provided. Satisfaction does not increase as the level of control increases. The presence or absence of some form of control is the most important factor.	1		
Display Space and Studios for Ideas, Processes, Projects and Products			
Display spaces for student (and teacher) work promote (mediate) student and teacher behavior and consequent academic improvement	1		
Display space for student work will enhance their self image and subsequently their academic performance	1		
Learning Environment Size			
The size of the learning environment will influence the seating arrangement and the way that teachers move about the classroom to interact with students	1		
Shape of Learning Environment			
The shape of the learning environment can influence the organization of seating that afford opportunities for group and individual work to occur simultaneously	2		
Spaces for Students to Personalize			
The ability for students to personalize their environment will affect their self image and minimize vandalism	1		

Appendix P (cont'd).

School Building Size			
The physical school size affects the possibilities for teacher-student-community interaction and consequent resulting cohesion or friction that may affect student academic progress.	1		We know school body size matters, does physical school size make a difference too, does it have an additive effect?
Professional Spaces for Teachers			
Professional spaces for teachers that include workrooms, and especially private offices, will create a sense of ownership in teachers that may lead to better attitudes toward their workplace and motivate them to improve their teaching practice that may lead to better teacher retention, lower teacher absentee rates and teacher/ administrator collaboration.	2		
Learning Spaces in the Community			
If the daily life of the school is well-integrated into the community, students will feel that their work is more meaningful, that the school is investing in their ongoing lives. Students will be more connected to the adult community around them, increasing their social development and reducing their transience. Local businesses will be more familiar with the students, more willing to engage them as customers and workers. Both students and parents will report increased satisfaction with the school.	3		
The school as the center of a community expands students awareness of education and promotes good citizenship	1		
Outdoor Learning Spaces			
Outdoor learning spaces will increase learning opportunities and affect student performance	2		

Appendix P (cont'd).

A Building of Niches			
Places for students to meet outside the classroom will promote social interaction and enhance their social skills	2		
Autonomy of Access to Group Work Area			
Autonomy of access to group work areas in schools that practice project-based education will create a sense of ownership in students that may lead to better attitudes toward school and motivation to learn that will positively influence their performance, greater student attendance and overall success in school, socially and academically.	1		
Location that is Convenient to Community Resources			Learning Spaces Within the Community
School location that is convenient to community resources (immediately adjacent/proximate to zoos, parks, libraries, partnering businesses) will be more likely to forge partnerships and joint use agreements that may lead to more contextualized, real-world learning for students (moderated by teacher quality – motivation to create and maintain these partnerships) that may lead to an improved sense of relevance of learning to their own lives, improve the social climate and culture within the school, build community capital that will overtime lead to the academic growth of students, greater attendance by students, teacher administrative retention, school connectedness, affective performance.	2		
Age of the School Building			
Students in old buildings will score lower on measures of achievement than will students in modern buildings.	1		

APPENDIX Q

RESEARCHER QUESTIONNAIRE COMMENTS REGARDING THE FRAMEWORK

Survey 4b: Summary of Comments	
	GENERAL COMMENTS
	Try to avoid the use of "and" since it implies two different concepts
	I reviewed all of the items, but I'm not sure they are very helpful to a researcher because of all of the non-intrinsic items that to my mind have nothing to do with how students perform or how successful students or the school is, yet educators seem to think they are important. They are important, but not for the progress of students or the school and educators tend to equate too many things about the whole structure of the organization and building with student success that have nothing to do with them, and further can never be tested.
	THIS SEEMS LIKE A HODGE PODGE LAUNDRY LIST, HOW DOES IT COMPRISE SOME KIND OF THEORETICAL MODEL? HOW ARE THESE CATEGORIES LINKED OR RELATED? ETC….QUESTIONS QUESTIONS…..;
FUNCTIONALITY	**COMMENTS**
Building Identity and Recognition	Building Identity, Recognition, and Ownership; Personalization
Infusion of students' culture into the fabric of the building	why isn't this in Sociality under a heading "Cultural Meaning and Communication or something like that"; A little confusing. Are "students" a proxy for the community? You may want to substitute "community" for students, unless you specifically mean "students' culture".

Appendix Q (cont'd).

Incorporation of student work into the school building	this is a personalization variable here in functionality?
Facility needs to "fit" the community in design and scale and should have an identifiable and recognizable "front door"	
Building Legibility	
Signage	
Relationship of spaces within building (i.e., how spaces for different types of activities are interconnected)	"Spatial Configuration" more general?; Relationship and visibility of spaces within building….etc.
Color and lighting for spatial delineation	delete "for spatial delineation"
Floor plan layout	
Interior materials	
Exterior materials	
Spatiality and Scale	Spatial Features
Size of school grounds	Size of school site; Move to Size
School building size (e.g., square footage)	Move to Size
"Schools within a school": learning "houses" with clear, identifiable boundaries if large school	I would change the word "boundaries" to spaces
Learning environment size (e.g., classroom square footage)	Think about what the word "classroom" denotes; Move to Size
Learning environment geometric shape (e.g., fat-L, square, rectangular)	How about no specific shape if space is flexible to be configured in many ways? How can you specify this if is open?
Scale of building elements relative to one another	Move to BL (building legibility?)
Academic Grade configuration (refers to the manner in which grade levels are organized into a single school, e.g. K-3, K-5, K-12)	K2, K8? 9th grade transitional facilities, K16? Its endless
Food service areas (location and accessibility)	
Informal gathering spaces	
Crowdedness or spaciousness	You could just refer to this either crowding or spaciousness, but this is a minor point - ; Size
Overcrowded conditions (possibly determined by % capacity for school achieved, square foot per child in the classroom)	change to classroom size
Size and shape of circulation spaces	
Space to keep items (e.g., coats, boots) from lying around and appearing "messy"	Storage Space; Move to Personalization

Appendix Q (cont'd).

Storage for teaching/learning supplies	
Flexibility	**Change to ?**
Site – the grounds that surround a school building (flexibility refers to having a site that accommodates diverse activities and changing needs)	
School building or buildings (flexibility may refer to the ability to add on or renovate to meet changing needs) also known as long range planning or master planning. Anticipation	
Learning environment (e.g., movable walls, portable equipment, etc)	redundant - omit?
Furnishings (seating that is comfortable and accommodating; diverse work surfaces - heights, sizes and shapes)	omit
Distribution of outlet to support information technology and provide electricity	wireless technology and ports?; add data ports and wireless capability; Omit
Moveable task lighting	
Instructional Support	Teaching and Learning Support? - get the master learner-centered paradigm in here somehow rather than having this sound teacher-centered?; Resource Spaces
Library	Access to and retrieval of information from a variety of sources and locations (a single library is fast becoming not as desirable)
Music rooms	
Creativity studios--art, sound, graphic	
Science laboratories	
Physical education facilities	
Professional spaces for teachers (including work rooms, lounges, offices, professional library)	What about location of offices There is a debate about whether administrative and guidance offices should be decentralized or centralized. Another issue concerns whether or not to cluster similar subjects in the same area or to distribute similar types of classroom throughout the school. Where to locate vocational classes, noisy classes (music, chorus, shop), lab classes, etc. is an issue receiving considerable attention.
Outdoor learning spaces (natural, man-made) - availability and their location	Move to Spatial Features

Appendix Q (cont'd).

Spaces for building models, art work, etc.	Spaces to conceive, design, build, test, and evaluate projects
	You might want to include a space for "other" since there may be uses in the future that we are not aware of now - computer labs? Or are they considered a core part of the curriculum, or are they in the rooms now, and not in a separate support role?
Space for community, business, and parent partners and volunteers	
Presentation space--small and large	
Conference and meeting spaces	
Conveniences	**Omit**
Lockable, personalized storage	Move to Personalization
Student accessible files (students create and maintain an individual learning plan, portfolio of learning evidence)	Move to Personalization
Secure storage of collective projects in process	Move to Safety and Security
SOCIABILITY	
Collaboration and social interaction	
Access to group work area (allows team members to work on projects as mood and/or opportunity strikes)	I see rows 57-63, and 70 as primarily instructional support--socialization occurs through the action of learning (modified so numbers match - Wolf)
Team workstations/shared spaces	
Spaces to accommodate different size groups	
Visible Presentation area – present acquired knowledge, skills and abilities	
A building of niches (allows many small groups to claim space and meet in regular locations)	Move to Spatial Features
Spaces for display of ideas, processes, projects and products	Move to Personalization
Spaces for production: design, testing and evaluation, and application of products (student developed – even products to sell)	
A town square (large area all pass through)	Move to Spatial Features
Commons areas appropriate for age group	

Appendix Q (cont'd).

Informal learning spaces where students, teachers, and staff can further learn beyond the confines of the "classroom"	
Space supporting multi-disciplinary activities	
Faculty collaborative space	
Conference spaces	Move to Spatial Features
Interior windows for viewing of instructional areas	
	where is territoriality (ownership issues)???
Privacy	Privacy and Individual Spaces
Spaces for quiet reflection (however created – furnishings, walls, doors, etc.) for both students and faculty	
Individual workspace (student "owned," allows a quiet home base, control of the modes of work)	Move to Personalization
Autonomy	Omit
Freedom of access to environment housing computers and library materials	Programmatic, not physical
Freedom of access to group work area	Programmatic, not physic al
Spaces for students to personalize	Move to Personalization
Multiple access points and time availability to food and beverages	Programmatic, not physical
COMFORT, HEALTH & SAFETY	
Acoustical comfort	
Interior noise (e.g., ambient, inside the learning environment)	
External noise (e.g., aircraft, highway)	
Acoustic privacy from other groups	
Individual control over acoustical conditions (e.g., closing of door and window)	
Visual comfort	
Natural lighting (e.g., windows, clerestories, skylights)	Daylighting
Electric lighting (general, task)	
Visual conditions (glare, contrast between print and paper, etc.)	

Views to the outside	
Individual control over visual conditions (e.g., illumination level)	
Thermal comfort	
Air-conditioning for cooling (e.g., presence, type)	
Heating	
Relative humidity	
Individual control over thermal conditions (e.g., ventilation, temperature)	
Indoor air quality (real and perceived)	take out real and perceived - this is understood; Move to Thermal comfort
Adequate ventilation	
Presence or absence of pollutants indoors (e.g., mold, VOCs, etc.)	
Safety and security (real and perceived)	take out real and perceived
Sight lines within building	
Child's perceived safety	
Telephones in classroom (more important as a resource for project-based learning when projects are community based, however, serve as a back-up security device)	
Site safety (visible entries, site lighting, alarms, etc)	
Let's add a category addressing multiple access and with more time options for food and beverages---individuals of all ages are better able to concentrate and function if these simple needs are met when their bodies need them.	
House school safety officers with easy access and visibility	
House community, business, and parent partners and volunteers throughout the building to add extra sets of adult eyes and create that sense of "safe presence."	
AESTHETICS & APPEARANCE	Omit
Sensory stimulation (appropriate, but not excessive)	Omit

Floor coverings	Omit
Wall coverings or treatments	Omit
Colors	Omit
Neat rather than chaotic display systems	who is to say that neat is always best?; Omit
ability to use music to stimulate thinking, reflection, or action	
ability to make announcements without "jarring" everyone's senses---perhaps use other means of media for that type of communication	
Maintenance	
Cleanliness (upkeep, sanitary conditions)	
Quality of learning environment conditions (appearance of furniture, walls, etc.; deteriorating plaster, water stains, paint condition)	
Age of the school building	
Building improvements/modernization	
RESOURCES	
Community Resources	
Visitors easily accommodated (parking, access, work areas)	
Proximity of school building to community	
Space for community and business representatives, volunteers, and parents within the school	instructional support and safety
Learning spaces within the community - shared spaces such as libraries, physical fitness centers, museums,	can also be instructional support
Small business incubator space	can also be instructional support
Technology Resources (students and staff)	
Computers and Internet access	
Accessible phone, copiers, fax – especially important if students are working with business and community partners in producing "real world" solutions	
School building as a teaching tool (e.g., observed power generation from solar panel)	

Appendix Q (cont'd).

Human Resources (within the school)	
Spatial integration of teachers, counselors and students for access to intellectual and career advice (advice is obtained without special trips through unwelcoming main administrative territory)	

APPENDIX R

LESSONS LEARNED ABOUT USING THE DELPHI METHOD

There are several lessons that have been learned with regards to utilizing a Delphi technique in this study. First, the method worked well and most of the goals of this phase of the research were met, with the exception of asking the panel members to suggest operational definitions for a subset of the variables. Although the researcher carefully thought about the how each of the four questionnaires would be structured ahead of time, each questionnaire turned out to be quite a bit different than anticipated in order to include the data received from the previous questionnaire. For example, the extremely wide variety of physical factors received in response to Questionnaire 1 was not anticipated because the researcher expected to receive a set consisting primarily of ambient conditions (e.g., lighting, thermal comfort). So, the development of the Framework was necessary to provide some order to the various physical attributes. In fact, so many more physical attributes were obtained than expected that the remaining 3 questionnaires were modified substantially. Below is a comparison of the questionnaires that were originally intended, and those that were actually used.

Appendix R (cont'd).

Originally Intended Questionnaires	**Actual Questionnaires**
Questionnaire 1: Brainstorm a list of physical school conditions that likely affect educational outcomes.	***Questionnaire 1***: Brainstorm a list of physical school conditions that likely affect educational outcomes.
***Questionnaire 2**:* Identify plausible relationships between school conditions and educational outcomes that educators believe are important.	***Questionnaire 2***: Rate the importance of physical factors identified in Questionnaire 1
***Questionnaire 3**:* Participate in a second round on Questionnaire 2 to gain some level of consensus	***Questionnaire 3***: Developing hypotheses to link physical factors with measures of success
Questionnaire 4: Recommend operational definitions or methods for measuring a subset of the variables identified in Questionnaire 2.	***Questionnaire 4***: Identifying High Priority Hypotheses and Finalizing the Framework

As a result of all of the necessary modifications, it is not surprising that questionnaire development and data analysis took longer than anticipated. Second, the scope of the Delphi study should be sufficiently narrow. In this case, a series of 4 questionnaires was used to develop a list of physical factors likely to affect educational outcomes, identify the most important ones, suggest hypotheses to study in the near-term and select those hypotheses that are most important. In hindsight, the scope of this phase of the study was perhaps too broad. It is unwise, it seems, to seek four types of outputs from just four questionnaires, particularly when some level of agreement is desired. Third, some of the respondents will tire of the demands for their time as the study progresses. In a Delphi study, the researcher must realize that some panel members will drop out. Fourth, if the questionnaire format is more "fun" to complete, the response rate may be higher. The format of Questionnaire 2, using the Free Online Questionnaires system, was simple to use. The respondent simply clicked on and importance rating for each physical item in Section 1. Although this approach required the respondent to think about whether or not the item was likely to affect educational outcomes, the process seemed to go quickly for most. The format for this questionnaire may have contributed to the higher response rate and the speed with which panel members could respond. The more cumbersome Excel files used in Questionnaires 3 and 4 perhaps required more intense thinking and were less visually attractive, possibly contributing to the lower response rate (combined with a loss of interest in participating). However, panel members were also asked to provide information in a manner that is more time-intensive than using a Likert-type scale (as in Questionnaire 2). Fifth, it is always good to "pilot" test each questionnaire before sending it out to the entire group. Even if there are no "experts" to spare, one or two can be asked to review or even take the questionnaire (as was done in this study) to find any problems with the questionnaires before they are widely distributed. If a questionnaire changes significantly, the pilot testers should be asked to take the questionnaire again.

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